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Injury and disease in the young Thoroughbred racehorse: Associations with subsequent racing performance

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Abstract

There is limited research detailing the precise reason for foals failing to achieve different life-stages from birth to racing, even though almost 50% of foals do not reach flat race training in the UK (Wilsher et al., 2006). In order to increase the proportion of the Thoroughbred foal population that reach the racecourse, a better understanding of the reasons behind failure and associated risk factors is required. The aims of this project were to:

- Identify veterinary reasons for foals failing to reach training and racing.
- Identify juvenile veterinary problems associated with reduced race performance.

Content analysis (Wordstat: Provalis Research, Canada), was used to extract information from a free-text dataset that included the histories of 1044 foals born within an international breeding operation between 2000 and 2004, inclusive. Chi-squared tests were used to identify associations between type of early career injury (prior to entering full training) and successful entry into training.

Further analyses explored associations between the three most common juvenile veterinary problems and performance in racing. Career profiles were collected for the entire cohort using the Racing Post's online dataset (www.racingpost.com). Information collected included; number of career starts, wins and places, prize money earned through winning a race, total prize money won, Official Ratings (OR's) and Racing Post ratings. Two sampled t-tests and Mann Whitney tests were used to identify associations between juvenile veterinary problems[1] and different measures of race performance. Šidák-Bonferonni corrections were used to adjust for multiple comparisons. Multiple linear regression models were used to account for potential confounding effects of other variables on performance (gender, year of birth and month of birth) and sire and dam were also included as a random effect in the model.

Of the original cohort, 56.5% (590) of horses entered full training successfully, while still under the ownership of the breeding operation. Sixty-one (7%) horses died before reaching this stage. Of these, 38% (23/61) failed to reach weaning and 62% (38/61) died either before entering training or before being sold post-weaning. A total of 717 horses (69%) were identified as having had at least one veterinary problem during their early years. Two hundred and fifty-seven horses were identified with no veterinary problems and 70 horses included insufficient data to identify whether they had veterinary problems. The most common veterinary problem identified was musculoskeletal injury or disease (excluding fractures) (MSK), with 50% (522/1044) of horses being affected, followed by fractures, 214 (21%), and the respiratory system, 179 (17%). Other problems identified included gastrointestinal, neurological, ophthalmic, infection and reproductive ailments.

[1] Early year veterinary problem that occurred prior to the horse entering full training

One hundred and three horses (9.9%) sustained a fracture before reaching an age when they would have entered training. Of these, 64 (62%) did not enter training under ownership of the breeding operation; of these 46 (72%) were sold or gifted before entering training, 13 (20%) died before entering training and the remaining five (6%) were still in pre-training or went directly to stud. A total of 326 horses (31%) sustained an MSK before reaching training age. Of these, 141 (43%) did not enter training under ownership of the stud; of these 109 (77%) were sold or gifted before entering training, 21 (15%) died before entering training and 11 (8%) were still in pre training or went directly to stud. Ninety one horses (9%) were identified with a respiratory problem prior to reaching training age. Of these, 48 (53%) did not enter training under ownership of the breeding operation; of these 43 (90%) were sold or gifted, four (8%) died before reaching training age and one (2.1%) was still in pre training. Horses that sustained a fracture during their juvenile years were significantly less likely to enter training compared with the remainder of the cohort (p-value <0.001). Of the original 1044 horses 658 (63%) horses raced at least once. Maximum and mean OR's were significantly reduced in horses that sustained a fracture prior to reaching training age (p-value <0.001). Gender was retained as being significantly associated with the outcome in multiple linear regression models (p-value <0.05) but adding sire and dam as a random effect did not significantly change any of the outcomes.

These analyses demonstrate the importance of avoiding serious injury during the first two-years of life for Thoroughbred racehorses. Although this study has identified the major priorities which could contribute to loss in the Thoroughbred breeding industry, further work is needed to identify and initiate potential management techniques that may help to minimise the risk of injury in the early years of a Thoroughbred's career.

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Declaration

I declare that, except where explicit reference is made to the contribution of others, that this thesis is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

Signature _______________________________

Printed name _______________________________

1 Literature Review

1.1 Introduction

There is limited research detailing the precise reason for foals failing to achieve different life-stages from birth to racing, even though almost 50% of foals do not reach flat race training in the UK (Wilsher *et al*. 2006). In order to increase the proportion of the Thoroughbred foal population that race at least once, a better understanding of the reasons behind failure and associated risk factors is required.

1.1.1 Horseracing

Thoroughbred horseracing is a popular sport in the United Kingdom (UK), with nearly six million spectators attending race meets in 2008. Regulated by the British Horseracing Authority (BHA), prize money in excess of £106,000,000 was awarded in 2008 after 9000 races that took place at one of the 61 UK racecourses. The industry provides over 88,000 jobs and is Britain's largest sporting employer, generating £1.2bn of profit for bookmakers alone (BHA Annual Review 2008). However, the industry would not be what it is today without the hard work that goes into producing a trainable athlete, capable of running races, and thus relies heavily on the owners, breeders and trainers of Thoroughbred racehorses.

Around 18,000 foals from the UK and Republic of Ireland are registered with the BHA's administration providers (Weatherbys) every year by one of numerous independent or international Thoroughbred breeding operations. Many of these foals change ownership at various sales before reaching pre-training or training age generating millions of pounds through private sales and bloodstock auctions, such as Tattersalls. In 2008, in excess of 15,000 horses were registered in training with one of the 600 licensed trainers in the UK who between them made over 98,000 appearances at one of the 1,400 race day fixtures.

1.2 Health problems affecting Thoroughbred racehorses in the UK

Several studies (Allen *et al*. 2007; Bailey *et al*. 1997b; Bailey 1998; Dyson *et al*. 2008; Jeffcott *et al*. 1982; Olivier *et al*. 1997; Rossdale *et al*. 1985; Wilsher *et al*. 2006) have investigated wastage and loss in Thoroughbred training and racing but there have been few reports detailing the causes of wastage from conception to maturity in racehorses. Wastage, or loss, has been used to refer to losses that occur at all stages of development of a racehorse, including mares failing to conceive or carry a pregnancy to term, morbidity or mortality in foals, and injuries associated with training and racing (Bailey 1998). A considerable amount of work has been conducted to investigate the sources of loss within the equine industry, with the identification of risk factors and preventive measures explored, particularly in the racing Thoroughbred (Allen *et al*. 2007; Bailey *et al*. 1997b; Bailey 1998; Dyson *et al*. 2008; Jeffcott *et al*. 1982; Olivier *et al*. 1997; Rossdale *et al*. 1985; Wilsher *et al*. 2006).

Reasons for lost training days and poor performance on race days have been explored widely, throughout the world, reporting that lameness and respiratory problems are the major reasons for loss (Dyson *et al*. 2008; Jeffcott *et al*. 1982; Olivier *et al*. 1997; Rossdale *et al*. 1985).

1.2.1 Breeding Stage

Losses at the breeding stage are reported to be mainly attributable to failure to conceive, abortion, twinning, and still births (Bailey 1998). Morley and Townsend (1997) also reported that dystocia was associated with a decreased likelihood of delivering live foals, and foals born after difficult deliveries had a significantly increased risk of morbidity and mortality, with 14% of dystocia cases resulting in death of the foal.

Failure to conceive has been reported to be a major cause of loss to the Thoroughbred breeding industry (Morris and Allen 2002). Even though the initial pregnancy rate in covered mares appears high, at 94.8%, the number of mares that carry a live foal to term has been reported as 77% (Rossdale *et al*. 1985), 80% (Morley and Townsend, 1997) and 82.7% (Morris and Allen 2002). Earlier studies reported that just 67% of mares produced a live foal applicable for naming in the 1973 to 1979 seasons (Jeffcott *et al.* 1982). The majority of these horses were named before reaching two years of age but a small proportion were not named until they were four years old. Knowing the major sources of loss within this area of the Thoroughbred industry has enabled the development of practices and technologies to increase efficiency. However, once these techniques have been applied successfully to maximize breeding returns, attention must be focused on producing a trainable athlete post-partum.

The risk of death in foals is greatest during the first seven days of life (Cohen 1994) accounting for 75% of all deaths up to two months of age (Platt 1979). In Texan farms, the major single causes of death in foals were pneumonia and septicaemia (caused by failure of transfer of colostrol immunity), although musculoskeletal disorders represented the most common cause of all deaths when considered as a group (Cohen 1994). Post partum deaths occurring within the first year of life have been reported as 11%; with almost 50% occurring during the first 14 days (Morley and Townsend 1997). In this study the most commonly reported problems occurring during the first 14 days were diarrhoea, angular limb deformities, and retained meconium or constipation. However these problems were associated with low case fatality. Conditions reported less frequently, such as pneumonia, septicaemia, or ruptured bladder, had much higher case fatality rates (100%, 70% and 67%, respectively). An increased risk of mortality and morbidity has been reported to be associated with increasing age of the dam. Foals dying within the first 14 days of life have been found to have significantly older dams (mean = 12.4 years) than foals that survived past 15 days of life (mean = 10.6 years) (Morley and Townsend, 1997). Jeffcott *et al.* (1982) also reported dam age as risk factor with the likelihood of a live foal decreasing as the age of the mare increased. For example 75% of mares aged four years produced a live foal whereas only 48% of mares aged 20+ produced a live foal.

Morley and Townsend (1997) followed 1120 breeding mares in Canada using owner questionnaires until one year post partum and reported a 6% mortality rate in foals between age 15 days and one year. Twenty seven percent of foals had a health problem within this time period with the most commonly observed being upper respiratory tract infections (11%), diarrhoea (3%), and angular limb deformities (3%). Nine percent of owners reported specific musculoskeletal conditions; angular limb deformities, contracted tendons, and laxity of the flexor tendons. Thirty six (4.5%) horses were reported in a category named 'Other', of which 40% included fracture, epiphysitis and umbilical hernia.

At one year of age, owners perceived 0.6% (n=4) of horses to be unacceptable for sales because of health problems occurring during the first 14 days post-partum. Horses with health problems in the first 14 days post partum were five times more likely to be deemed unacceptable for sale than the rest of the cohort. Health problems including weakness or depression, angular limb deformities, or joint or tendon laxity were most strongly associated with being deemed unacceptable for sale (Morley and Townsend 1997). Horses with health problems occurring between 15 days and one year were seven times more likely to be regarded as unacceptable for sales. In this group horses with angular limb deformities were 24 times more likely to be unacceptable for sale than those foals without a health problem.

O'Donohue, Smith and Strickland (1992) reported that 68% (n=168) of Irish Thoroughbred foals from 17 stud farms exhibited some form of developmental orthopaedic disease, with 12% (n=20) of these ultimately requiring treatment. The most commonly observed problems were angular limb deformity followed by physistis, which together constituted 73% of cases treated. Nineteen percent of those treated were considered unfit for sale, lost considerable value, or were humanely destroyed.

1.2.2 Horses in Training and Racing

Wastage or loss during training and racing has been well documented in the UK and internationally. Owner and trainer surveys, together with information available on public datasets (e.g. www.racingpost.com) detailing racing careers of individual horses are common methods of assessing loss within this industry area (Allen *et al*. 2007; Bailey *et al*. 1997b; Bailey 1998; Cogger *et al*. 2008a; Cogger *et al*. 2008b; Dyson *et al*. 2008; Jeffcott *et al*. 1982; Olivier *et al*. 1997; Rossdale *et al*. 1985; Wilsher *et al*. 2006).

The proportion of horses entering training as two year olds was reported as 54% by Wilsher *et al.* (2006), with the mean number of starts for all horses being 1.97, and 3.25 for horses that raced at least once. However, 39% (n=210) of two year olds did not run at all. For three year olds, the mean number of starts for all horses was 4.02 and 5.29 for those that raced at least once. Eighty percent of the two year olds remained in training as three year olds but it is unclear how many of the three year olds were unraced as two year olds i.e. their first year in training, in which they raced, was as a three year old. Similarly, in a study published by Jeffcott *et al.* (1982), in which the 1975 UK foal crop was investigated, it was reported that only 50% of the study cohort raced as a two, three, or a four year old and given that 62% of the total horses in this study entered training, this demonstrated a 12% loss in training and racing.

When considering financial returns, Wilsher *et al.* (2006) found that two year olds won a mean of £2646 with a median of £0, and three year olds won a mean of £7378 with a median of £285. Assuming a basic training fee of £10000 per annum, just 5% of two year olds, and 17% of three year olds covered these costs through their race earnings.

1.2.2.1 Veterinary Problems

Veterinary problems leading to lost racing and training days have been reported to account for 8.1% and 8.5% of total potential racing and training days (Olivier *et al.* 1997; Rossdale *et al.* 1985). These figures have also been reported to be as high as 26.8% and 21.53% (Dyson *et al.* 2008). However, in the latter study (Dyson *et al.* 2008) the definition of a lost training day differed, with all non-management/rest days when horses did not perform exercise at slow canter or faster being counted as lost, and all days subsequent to death or retirement due to injury also counted as lost for the duration of that training year.

Contributions to wastage, or loss, within flat racing and training have been reported as being ‘unsoundness’ and lack of ability by Jeffcott *et al.* (1982) and Wilsher *et al.* (1996). Eighteen percent of two year olds and 23% of three year olds have been reported to ‘lack ability’ by their trainers in the study by Wilsher *et al.* (1996). Other studies have also focused more closely on specific veterinary conditions that contribute to lack of performance (Kasashima *et al.* 2004; Lam *et* *al*. 2007a; Parkin *et al*. 2004a; Perkins *et al*. 2005). Musculoskeletal conditions, poor performance, immaturity and respiratory problems are widely reported as being major contributing factors (Bailey 1998; Cogger *et al*. 2008a).

When looking at specific reasons for an inability to train on any specific day 'shin soreness' (Dorsal Metacarpal Disease (DMD)) has been frequently observed by 60-80% of trainers in Australia and the United States and is considered to be a major cause of wastage (Bailey *et al*. 1997b; Cogger *et al*. 2008a). 'Sore shins' were also found to be the most common problem in two year old Thoroughbreds in UK training yards (Wilsher *et al*. 2006), with 29% of horses being affected. The higher incidence in Australia and the United States has been suggested to be related to training on oval-shaped dirt tracks rather than straight grass gallops, as in the UK (Wilsher *et al*. 2006). Wilsher *et al*. (2006) also noted a lower prevalence of shin soreness in three year olds. The number of training days lost due to shin soreness for 2 year olds being 150 compared to 53 for three year olds. With increased maturity and exercise the third metacarpal bone of the horse changes shape so as to lower the compressive strain at high-speed exercise and it has been hypothesised that this adaptive change may contribute to this difference between two and three year old horses (Nunamaker *et al*. 1990).

Veterinary problems were seen in 62% of two year olds and 50% of three year olds in a cohort of 1022 horses (Wilsher *et al*. 2006). The most commonly reported problems in both two and three year olds were 'sore shins' (29% and 12% respectively), inflammatory airway disease (13% and 8% respectively), joint problems (11% and 13% respectively) and fractures (10% and 9% respectively). Several papers have reported lameness as the major cause of lost training days in flat racehorses (Bailey *et al*. 1997b; Dyson *et al*. 2008; Jeffcott *et al*. 1982; Olivier *et al*. 1997; Rossdale *et al*. 1985) with up to 53% of animals experiencing a period of lameness within study groups (Jeffcott *et al*. 1982) and accounting for up to 72% of veterinary problems contributing to wastage (Olivier *et al*. 1997; Rossdale *et al*. 1985). In German Thoroughbreds, 57% of training failures, defined as an inability to be trained at galloping pace, were due to lameness (Lindner and Dingerkus 1993). Dyson *et al*. (2008) reported that lameness accounted for approximately 20% of all training days lost which is higher than previously reported in the UK (5.8% (Rossdale *et al*. 1985)), South Africa (8.1% (Olivier *et al*. 1997)) and Australia (2.7% (Bailey 1998)). Dyson *et al*. (2008) and

Rossdale *et al*. (1985) included days where horses did not perform exercise at slow canter or above for reasons of injury or disease as a lost training day. The difference in percentage days lost between Dyson *et al*. (2008) and Rossdale *et al*. (1985) may also be explained by the fact that the former also included horses that died or retired due to injury as having lost training days for the remainder of that particular training year.

Comparisons made between different horse age groups have also been made in a number of studies (Bailey *et al*. 1997b; Dyson *et al*. 2008; Jeffcott *et al*. 1982; Olivier *et al*. 1997; Rossdale *et al*. 1985). Olivier *et al*. (1997) reported lameness incidence to be higher in three year olds than two year olds, whereas, Dyson *et al*. (2008) reported similar lameness incidences in both age groups with lameness accounting for 81.5% and 82.6% of total days lost for two and three year olds, respectively. However, two year olds were at greater risk of suffering a lameness that resulted in more than 30 days lost from training compared to three year olds (Incidence Rate Ratio = 1.32, 95% CI = 1.04-1.51, P=0.03). Although lameness has been more frequently observed in three year olds in South Africa it should be considered that two year olds have a lower number of starts than three years olds which may account for the lower prevalence of lameness within this group (Olivier *et al*. 1997). The reduced number of starts in 2 year olds is at least partially due to the fact that, under the Jockey Club of Southern Africa rules, Thoroughbred racehorses in South Africa are not allowed to race until October of their 2nd year so a typical “race year” for a 2 year old would be slightly shorter than that for a 3 year old.

Respiratory disease has been reported to be the most common medical condition in two year old Thoroughbred racehorses (Dyson *et al*. 2008). When looking at both two and three year olds, respiratory disease has been found to be present in 14% and 13% of all horses respectively (Dyson *et al*. 2008; Wilsher *et al*. 2006). A higher percentage of two year olds with respiratory was also reported in the study by Rossdale *et al*. (1985) (2.3% and 0.9%, respectively). The relatively low prevalence in the latter study may, in part, be due to the development of improved diagnostic techniques and technologies that are present in more recent studies. Olivier *et al*. (1997) also reported a difference in respiratory problem incidence between two and three year olds; however, in this instance there was a higher prevalence in the older age group. Again, this may be accounted for due to the greater number of races attended by three year olds in Southern Africa thus increasing the risk of exposure to pathogens. UK studies (Herzog *et al.* 1993a; Rossdale *et al.* 1985) have reported that wastage due to respiratory problems represents ~21% of total days lost from training and racing, which is much higher than that reported by Olivier *et al.* (1997) (8.6%).

1.3 Developmental factors associated with injury

Musculoskeletal injury has been consistently documented as the primary reason for economic loss or wastage in Thoroughbred racing (Bailey *et al.* 1997a; Bailey *et al.* 1997b; Jeffcott *et al.* 1982; Rogers *et al.* 2008b) and wastage through injury remains a significant worldwide problem (Rogers *et al.* 2008a). Although some injuries are due to unavoidable trauma, most are related to exercise-induced cyclical trauma (Pool 1996) where the ability of the musculoskeletal system to adapt to the increased training load is exceeded (Rogers *et al.* 2008a). In human athletes, conditioning, training and competition are commenced before skeletal maturity (Smith *et al.* 1999). However, prior to more recent studies (Dingboom *et al.* 2002; Eto *et al.* 2003; Lepeule *et al.* 2009; Moffat *et al.* 2008; Parkin *et al.* 2004a; Parkin *et al.* 2005; Rietbroek *et al.* 2007; Rogers *et al.* 2008a, 2008b; Stanley *et al.* 2008; van Weeren *et al.* 2008), the racing of young Thoroughbreds (age 2 years) has been a contentious subject and questions have often been raised as to whether the horses involved are physically mature enough to cope with the intense physical training that they are subjected to or whether race-speed competition is necessary for optimum physical development (Smith *et al.* 1999).

1.3.1 Early response to exercise

In mature animals, training workload initiates a response of musculoskeletal tissues that may enhance tissue development and hence strengthen the systems involved (Rogers *et al.* 2008b). Recent studies on the influence of exercise in mature Thoroughbreds have shown that bone, tendon and joint tissues respond to different exercise volumes (Rogers *et al.* 2008a) and there is increasing evidence that musculoskeletal tissues, including those refractory to stimulation by workload in young mature animals, can be conditioned by early exercise, confinement or an interaction of both exercise and confinement during their early growth phase (Helminen *et al*. 2000; Rogers *et al*. 2008b)

1.3.1.1 Bone

Bone is known to respond quickly to changes in its mechanical environment, ensuring that bone mass and architecture are appropriate for the loads it is required to withstand (Brama *et al*. 2002; Nilsson and Westlin 1971; Rogers *et al*. 2008a; Rubin and Lanyon 1984), with failure of this adaptive response potentially leading to injury (Brama *et al*. 2002). Experimental studies have shown that bone cells are directly sensitive to mechanical influences (Brama *et al*. 2002) and there is also increasing evidence in the literature that shows the developing human skeleton is far more sensitive to the effects of loading than that of adults (Boot *et al*. 1997; Brama *et al*. 2002; Ruiz *et al*. 1995; Slemenda *et al*. 1991), giving reason to investigate these effects in other species. In the horse, exercise has been extensively shown to have a positive effect on bone density (Buckingham *et al*. 1992; Firth *et al*. 1999; Jeffcott *et al*. 1982), with the effect being most evident in young individuals (Cornelissen *et al*. 1999; Firth *et al*. 1999). Studies describing the effects of exercise on the organic matrix of equine bone have as yet not been undertaken, however it has been shown to affect the organic matrix of long bones in young mice (Kiiskinen and Heikkinen 1978), suggesting there is scope for further investigation.

1.3.1.2 Tendon

Few data exist on the effect conditioning has on tendons but in the few short- and long-term studies conducted no evidence of adaptation to exercise has been demonstrated (Birch *et al*. 1998). Superficial digital flexor (SDF) tendonopathy is a significant cause of wastage in Thoroughbred racehorses, being a potentially career-ending injury (Dowling *et al*. 2000; Lam *et al*. 2007a; Moffat *et al*. 2008; Perkins *et al*. 2004; Williams *et al*. 2001). Supporting tendons, such as the SDF, must undergo high strains to store sufficient amounts of energy for locomotion and, therefore, work close to their mechanical limits with correspondingly high rates of injury (Patterson-Kane and Firth 2008). Tendon injury often follows a failure to adapt to a variety of stresses, resulting in an undefined period of accumulation of age- and exercise-related micro damage (Kannus 2000; Patterson-Kane and Firth 2008). Tendonosis occurs when matrix breakdown overwhelms the cellular repair mechanisms, with inappropriate cellular synthetic responses to the microdamage and possibly increased amounts of cell death resulting in further weakening of the matrix (Patterson-Kane and Firth 2008). Tenocytes are thought to be constantly repairing damage under normal circumstances, otherwise all tendons would eventually weaken and rupture (Ker 2002), but excessive repetitive loading may cause direct damage to the matrix that cannot be repaired.

Because tendon responses to training have been reported as being limited, attention has turned to examining whether tissues of very young horses might have the capacity to respond to exercise by adaptive change that would be advantageous to future function. However, as yet, no conclusive evidence has been produced with findings suggesting that spontaneous pasture exercise may induce maximal development of energy storing tendons (Moffat *et al*. 2008).

1.3.1.3 Joint

Orthopaedic ailments are reported to be the main source of wastage in performance horses (Olivier *et al*. 1997; Rossdale *et al*. 1985) with joint-related problems predominating overall (Pool 1996). Joints can be influenced by mechanical stimulation (Smith and Goodship 2008) but substantial overloading or overuse can lead to gradual degeneration of the tissue, with eventual development of clinical lesions or developmental joint disease (Kim *et al*. 2009). Joint disease carries a poor long-term prognosis because of the very poor regenerative capacity of articular cartilage, which can be explained by the long turnover times of the components of the extracellular matrix in mature individuals (van Weeren *et al*. 2008). Whereas bone is responsive to biomechanical loading throughout life, the modelling of the collagen network of articular cartilage seems to be a once in a life time process, with the window of opportunity for the process appearing to be principally in the first 6 months *post partum* (Brama *et al*. 2000) with only few aspects still being subject to exercise-related modification at a later date. Investigations into the use of early exercise before the athletic phase of training, to enhance the adaptive potential of joint tissues, have reported no negative influences on the prevalence of gross defects in cartilage, suggesting that early conditioning exercise may be used without negative consequences (Kim *et al*. 2009). In addition, studies by (van de Lest *et al*. 2002), showed a lack of exercise had an adverse effect on the development of the normal adult pattern of matrix variation across the joint however these joints were able to ‘catch up’ with the introduction of a normal exercise level. Nevertheless, foals given a high level of imposed exercise alone (with no pasture exercise), exhibited some reductions in their ability to compensate later, suggesting that regular submaximal loading is important for healthy cartilage development (Smith and Goodship 2008). Furthermore, recent studies have also confirmed that subjecting foals to conditioning exercise early in life does not have adverse effects on racing careers at ages 2 and 3 years, and does not influence the workload needed to reach a fitness level that is sufficient for racing (Rogers *et al*. 2008b).

1.3.2 Summary

It is apparent that specific loading regimes have different effects on different tissues, suggesting that a generic holistic approach to training the entire animal is needed. Given that different tissues mature at different times there is thought to be potential to introduce specific loading patterns during development that aim to optimise tissue structure and increase strength, thus potentially creating a more trainable athlete (Smith and Goodship 2008).

1.4 Epidemiological approach to investigation of health problems

The use of observational studies and resulting large datasets have proved very useful in the investigation of both medical and veterinary problems in the past (Dohoo *et al*. 2003). In these studies investigators endeavour to not influence the natural course of events for the study subjects, but confine their activities to carefully observing the study subjects with particular attention paid to the exposure and outcomes of interest (Bailey 1998; Lam *et al*. 2007a; Lam *et al*.

2007b). Observational studies can often take advantage of the fact that exposed subjects already exist. Therefore with an appropriate study design the impact of these exposures can be investigated without having to expose study subjects to the exposure.

The use of large, retrospective datasets means that both the exposure and the outcome have already occurred prior to the beginning of a study and thus the study usually relies on pre-recorded data from one or more secondary sources. Although the availability of this data is an advantage, the quality and the scope of the data can have limitations. Therefore, to allow for useful information to be mined from these information-rich retrospective studies, there is a requirement for a methodology to selectively extract the necessary information from the dataset.

1.4.1 Content analysis

Content analysis uses data mining to retrieve specific information from free-text. This is ideal for clinical records (such as veterinary reports) although, up until recently, has rarely been used in veterinary and human medicine, being more predominantly used in the social sciences to classify the content of open questions (Lam *et al*. 2007b). More recently, Lam et al (2007b) successfully used content analysis to extract reasons for equine retirement from the Hong Kong Jockey Club from over 3700 free text clinical records. The most important element of content analysis is the development of a categorisation scheme by which information can be classified with a degree of validity (Weare and Lin 2000).

Computerised medical records are now commonplace in human and animal health (Bass 2001; Crowe 2003; Hassey *et al*. 2001; Hornof *et al*. 2001; McCurdy 2001), and represent a fundamental change in data availability (Lam *et al*. 2007b). In addition to the medical/veterinary professions, computerised records are widely used in other industry areas to enhance the management and efficiency of large operations. Specifically, in the equine industry, these methods are widely used in the management of stud farms and racing stables. In these situations they readily allow complete training and/or racing histories of individual horses to be examined. In the case of the current study this enables one to search these information rich datasets for specific information more quickly than has previously been possible.

Language is important when considering content analysis. In the UK, clinical coding classification systems, such as OXMIS (Oxford Medical Information Systems), are used in medical systems, acting as a reference standard for primary care. However, no such standardisation has been widely accepted in veterinary systems (Lam *et al*. 2007b). Unknown words in records, including addresses and spelling errors, present further difficulties in content analysis (Heinze et al 2001, DeBrujin and Martin 2002). Nevertheless, the availability of large text data sources and software to extract specific features of that data opens up numerous opportunities for clinical research in many different settings.

1.5 Aims of study

Although studies have been conducted investigating juvenile health problems and acceptability for sale (Morley and Townsend 1997), the vast majority of studies have focused on health, or veterinary problems that occur during training and/or racing. Given the opportunity to work with stud-level data it is possible to ascertain how juvenile veterinary problems [2]may affect an individual's suitability to train or race. This will aid in the identification of priorities that are potentially major causes of loss in the Thoroughbred breeding and racing industries. The results of these studies will inform the design of further studies to investigate risk factors for the major veterinary causes of loss. Ultimately the aim is to implement interventions to reduce the population impact of risk factors so as to minimise loss.

The main aims of this study were:

- To identify veterinary reasons for foals failing to reach training and racing.

[2] Early year veterinary problem that occurred prior to the horse entering full training

- To examine the hypothesis that juvenile veterinary problems are associated with reduced race performance.

2 Materials and Methods

2.1 Study design

A retrospective study of veterinary records, provided by a large international breeding operation, was conducted. Content analysis was used to identify and classify records into different categories of veterinary problems and conditions. The frequency of common conditions was compared for each of the final status (most recent status under ownership of the breeding operation) outcomes of the study cohort. Conditions were identified that occurred prior to horses going into full training under ownership of the stud. The racing history of the whole cohort was used to asses whether early medical history was associated with subsequent racing performance.

2.1.1 Data

The dataset was provided by a large, international Thoroughbred breeding operation. The records were exported from the stud's management system in the form of Access (Microsoft) datasets and were provided for all UK based or horses that had been in the UK at some point between 2000 and 2006 (the time period included within the dataset). For the purpose of anonymity, all horses were given individual codes, or Horse ID's.

All records, for all horses born between 2000 and 2006, from birth until their departure from the breeding operation were available for analysis. Individual records were presented as veterinary procedures. The procedures ranged from routine procedures, such as observations, worming and vaccinations, to more specific procedures such as orthopaedic surgery. Procedure entries named 'veterinary report' contained large volumes of clinical free text (see Appendix 3). These reports often followed veterinary investigation of a condition and often contained a diagnosis. Keywords within the free text were identified that provided information regarding the body system with which the procedure record was associated. Some keywords were identified that also provided more specific detail, such as clinical signs, or specific diagnoses.

Initial investigations of the dataset were conducted by running queries in Access (Microsoft) to ascertain the total size of the cohort and the range of procedures recorded. Many procedures provided no indication of the condition being reported and were considered irrelevant for the purpose of this study. For example a procedure named ‘Veterinary X’ that had no accompanying report. Prior to content analysis, records for these procedures were removed in order to reduce the overall size of the dataset and to prevent unnecessary manual input after analysis.

2.1.2 Content analysis

Content analysis was conducted using Wordstat v 5.1(Provalis Research, Quebec, Canada), a modular component of the statistical software SimStat v 2.5 (Provalis Research, Quebec, Canada). The software allowed exploration and categorisation of columns of free-text records, using a user defined dictionary and additional tools such as lemmatisation (identification of the stem of a word) and exclusion dictionaries (containing commonly used words such as ‘in’ and ‘the’) that were then ‘ignored’ by the software.

The data were divided into individual years before running through the content analysis software so that any inconsistencies between years or trends on the prevalence of different veterinary problems could be identified. These data were then combined to represent results from the whole cohort.

Categories within the dictionary were based on the categories used by Lam *et al* (2007). The dictionary categories were refined by use of manual exploration of the data and through use of the ‘phrase finder’ function within WordStat. This function counts the words and phrases within the dataset, allowing identification of the most commonly used words and phrases, common spelling errors and abbreviations. A complete list of all words and phrases contained within each category within the dictionary is provided in Appendix 1. These were the final lists of keywords and phrases used to identify common veterinary problems from the whole dataset.

2.1.2.1 Veterinary Problems

Veterinary categories were defined as detailed below and were included based on previous studies reporting thoroughbred loss (Bailey 1998; Lam *et al.* 2007b) as well as investigation of the common equine veterinary ailments within the dataset.

Dermatological – conditions relating to the skin including sarcoids, mud fever, rain scald and ringworm

Fore limb lameness - any fore limb lameness identified by the breeding operation that required some form of veterinary investigation, intervention or treatment

Fracture – any bone fracture affecting any part of the body. This included chip fractures, the size of which was not always specified, but specifically excluded small chip fractures noted as part of osteochondrosis dissecans (OCD). Traumatic and non-traumatic fractures were both included and confirmed by radiographic, ultrsonographic and/or scintigraphic reports within the dataset.

Gastrointestinal – any gastrointestinal condition including colic, stomach ulcers, parasites and umbilical hernias.

Hind limb lameness - any hind limb lameness identified by the breeding operation that required some form of veterinary investigation, intervention or treatment

Infection – conditions including Equine Herpes Virus, Equine Infectious Anaemia, Equine Viral Arteritis, equine influenza, pyrexia, *Rhodococcus equi*. and abscesses

Musculoskeletal injury or disease, excluding fractures (MSK) - conditions affecting the bony structures (excluding fractures), joints and soft tissues of the musculoskeletal system including ligaments and tendons, such as conformational deformities, degenerative joint disease (including arthritis and osteochondrosis), joint sepsis and bone cysts.

Neurological – conditions affecting the nervous system such as compression of the spinal cord and clinical signs, such as ataxia, that are not associated with fracture.

Ophthalmic - conditions affecting the eye including cataract, corneal ulcers and eye/eyelid trauma

Reproductive-Male – conditions affecting the male reproductive system including cryptorchidism, veneral disease and reasons for castration.

Reproductive-Female – conditions affecting the female reproductive system including endometritis, abortion, uterine cysts, mastitis and vaginal prolapse.

Reproductive-Foal – conditions affecting foals immediately post partum including retained meconium, failure of colostral immunity transfer and haemolytic foal disease.

Respiratory – conditions affecting both the upper and lower respiratory tract including developmental and acquired problems such as recurrent laryngeal neuropathy, soft palate instability, nasal discharge, coughing and epistaxis/exercise induced pulmonary haemorrhage.

2.1.2.2 Data Output

A data matrix was produced by WordStat that recorded the occurrence of a keyword as a binary event within each record for each of the thirteen veterinary categories. Due to the nature of free-text, each record may have been classified into single or multiple categories. From this binary output the number and identity of horses classified as having at least one occurrence of each categorised condition was determined.

2.1.2.3 Clinically significant records

Records identified through key-words in WordStat that were clinically insignificant were removed from the resulting key-word search after manual examination of exported data. For example, all yearlings undergo routine pre-training endoscopy. As words within the dictionary identify this as a respiratory problem all records detailing the procedure were removed and only records that identified a respiratory problem, following the endoscopic examination, were retained. Additionally, all horses undergo a full radiographic screening process before pre training or training. These ‘screenings’ are graded based on the findings as reviewed by a veterinary surgeon. The overall grading is on a scale from I to IV, but significant lesions, such as sesamoitiditis and *Osteochondritis Dissecans* (OCD), within the report are graded from 1 to 3. After consultation with the veterinary surgeons at the breeding operation horses with an overall grade of III+ or with a lesion rating above 2 were deemed to have a clinical problem and therefore retained. Records for horses with lower overall or specific lesion grades were deemed not clinically significant and therefore removed from the output data.

Once all clinically relevant conditions had been identified in Excel, records for each category were imported into Access and linked to individual horse identifiers, allowing the retrieval of the full medical history for all horses that sustained a veterinary problem and providing a complete list of horses for each veterinary category.

2.1.3 Final Status

The original dataset contained two fields entitled “comment” and “horse location” which were used to categorise the eventual outcome for all horses born within the breeding operation. For example a horse’s final recorded location could have been ‘Tatersalls’, indicating that the horse had been sold. This information was used to determine the numbers of horses that, for example, went into training under ownership of the breeding operation and those that were sold before going into training. A complete list of all potential final statuses along with coding for further analysis is provided in Table 1. This enabled associations between veterinary problems and the final status of horses to be identified.

Table 1. Final Status information.

Status	Code for future analysis
Still a Foal	F
Deceased	HD
Sold as Foal	HSF
Sold as 1yo	HS1
Sold as 2yo	HS2
Sold as 3yo	HS3
Sold as 4 yo	HS4
Into training and sold as 2yo	TS2
Into training and sold as 3yo	TS3
Into training and sold as 4yo	TS4
Into training and sold as 5yo	TS5
Into training and sold as 6yo	TS6
1yo in pre training	PT1
2yo in pre training	PT2
3yo in pre training	PT3
1yo in training	HT1
2yo in training	HT2
3yo in training	HT3
4yo in training	HT4
Broodmare	Broodmare
Stallion	Stallion
Gifted	Gifted
Foal share	Foal share

The categories in Table 1 were summarised (for simplicity) for data analysis as follows;

- **F** – The last recorded entry for the horse was when it was a foal (mainly the 2006 foal crop)
- **HD** – A horse that died or was humanely destroyed
- **HS** – A horse that was sold by the stud without entering full training under their ownership
- **TS** – A horse that entered training and was subsequently sold
- **HT** – Horse was currently in training at the end of the dataset period
- **Broodmare** – A female horse undertaking stud duties
- **Stallion** – A male horse undertaking stud duties
- **Gifted/foal share** – horse that is involved in a stud gifting or sharing scheme scheme after which no records appear in the dataset.

The number of horses within each final status was used to determine the percentage of the original cohort that went into pre-training, training and racing.

2.2 Cohort selection: 2000-2004

After initial analysis, the data were filtered further to investigate the final status of horses affected by the three most prevalent veterinary problems identified by content analysis i.e. MSK, fracture and respiratory. The complete dataset included all horses born between 2000 to 2006, inclusive[3]. However, in order to be able to investigate associations between these three common veterinary problems and final status, horses had to have had the chance to reach training. In other words horses born in 2005 or 2006 would not have been old enough by the end of 2006 to have been in pre-training. Therefore, only horses born between 2000 and 2004 that had the chance to reach training age within the dataset period were included in this analysis (i.e. reach two years of age).

The dataset was further refined by identifying which of the veterinary problems occurred prior to entering full training i.e. in the horses first two years of life. Horses that sustained one (or more) of the three most common veterinary problems were identified and their records transferred into a new dataset, within which three data tables were created containing the following:

1. Horses identified as having sustained at least one MSK problem prior to entering training.

2. Horses identified as having sustained at least one fracture prior to entering training

3. Horses identified as having at least one respiratory problem prior to entering training.

These three types of veterinary problem were used to determine whether a horses' early medical history was associated with the likelihood of entering full training. Sub categories within categories, such as proximal sesamoid bone fractures within the fracture category, were also analysed in order to examine the association between specific veterinary diagnoses and subsequent race performance. Horses could have more than one occurrence of each of the three types of veterinary problems but they would only be included in the relevant category once. Horses could also appear in more than one of the categories if

[3] This refers to the veterinary problems that affected those horses at least once.

they sustained more than one of the three types of common veterinary problems.

2.2.1 Statistical Analysis

Univariate chi-squared analysis was used to compare horses within each veterinary category with the rest of the cohort (unaffected by the particular veterinary problem) to identify associations between the likelihood of making it into training and the occurrence of MSK, fracture or respiratory problems early in life. The analyses were performed using Epi Info Version 3.5.1 (CDC, USA). These analyses were designed to investigate the following hypotheses:

H1: Horses that sustained one or more MSK during their early career were less likely to enter full training than the remainder of the cohort.

H2: Horses that sustained one or more fractures during their early career were less likely to enter full training than the remainder of the cohort.

H3: Horses that sustained one or more respiratory problems during their early career were less likely to enter full training than the remainder of the cohort.

2.3 Performance data

In order to investigate further the potential association between early life MSK, fracture and respiratory problems and subsequent racing performance, race records for all horses that made it into training (both within and outwith the breeding operations ownership) were examined in detail. Two further categories were also created; horses that sustained just a fracture of the limb, and horses that sustained a fracture **and** an MSK. Using the Racing Post’s online dataset (www.racingpost.com), and horse names provided by the breeding operation, a summarised career profile was created for all horses, born between 2000 and 2004, that started at least one race in the UK.

A number of horses that were sold by the breeding operation before entering training only had a temporary name comprised of their Dam followed by their year of birth e.g. ‘<Dam’s name> 01’ provided by the stud. In order to retrieve these horses’ performance data it was necessary to identify the name given to the horse either when they went into training or when the horse was sold. This was possible by searching the racing post dataset for all of the dam’s progeny and identifying the horse born during the relevant year.

Performance data collected for each horse included: number of lifetime starts, number of lifetime places, money earned through winning races during career, total money earned in during career (including money earned through places), career maximum Racing Post rating[4], career mean Racing Post rating, career maximum Official rating[5] and career mean Official rating.

Once performance data for horses within our dataset was obtained, the information (using horse ID’s) was linked with the five veterinary categories (MSK, fracture, respiratory, limb fracture and fracture **and** MSK) using Access (Microsoft) so that there was a career profile for each horse in each category. Horses with a career profile that were unaffected by the veterinary category being investigated acted as controls for analysis.

[4] Racing Post ratings are a merit rating based on the horses’ past performances and adjusted for the condition of the day’s race. The highest rating is regarded as the horse with the best chance of winning i.e. the perceived best horse in the race (http://thebettingsite.racingpost.co.uk/news/show_story.sd?story_uid=915157).

[5] Official ratings are merit ratings assigned to horses based on past performances by a team of handicappers working for the Horseracing Authorities (in the UK this is the British Horseracing Authority). In Britain, their primary purpose is to determine the weight each horse should carry in handicap races. Horses must carry 1lb of weight more for each point they are higher in the handicap than other horses[5] in the official ratings when contesting handicap races. In non-handicap races Official ratings can be used like Racing Post ratings to assess each horse’s chance, but in handicaps, the weight adjusted Official rating for each horse will be the same. Official ratings are used to represent ability of the horse (http://thebettingsite.racingpost.co.uk/news/show_story.sd?story_uid=915159).

2.3.1 Statistical Analysis – measures of performance

Data were tested for normality of distribution and equality of variance using Minitab Version 12.1.2 (Minitab Inc, USA).

Histograms for each performance variable (number of career starts, wins, places, career winnings (£), career earnings (£ - winnings + money earned in placings), maximum Racing Post Rating (RPR), mean RPR, maximum Official Rating (OR) and mean OR) were produced to examine the distribution of data and assess degree of skewness. Histograms for each performance measure are provided in Appendix 2. Descriptive statistics (including mean, median etc.) were produced for all performance variables. Complete descriptive analyses are also provided in Appendix 2.

Performance data within each category (fracture and no fracture; MSK and no MSK; respiratory problem and no respiratory problem; limb fracture and no limb fracture; fracture **and** MSK and no fracture **and** MSK) was tested for normality using the Anderson-Darling test. Descriptive statistics were also generated for each performance variable within each veterinary problem category. Equality of variances was examined for each pairwise comparison for which two sample t-tests were to be performed (i.e. data that were shown to be normally distributed). To examine the association between the presence of early career veterinary problems and subsequent racing performance either a two sampled t-test or the Mann-Whitney test was used. Šidák-Bonferonni corrections were used to adjust for multiple comparisons.

2.3.1.1 Multiple linear regression

Multiple linear regression models were developed using STATA (StataCorpLP, College Station, Texas, US) by manual selection of explanatory variables to investigate the potential confounding effect of gender, year and month of birth on the associations between fracture/limb fracture and mean OR; fracture/limb fracture and maximum OR; fracture and MSK; and mean OR and maximum OR. Variables were retained if, when added to the model, their associated p-value remained <0.05. The potential effect of confounding by all variables not included in the final model was also checked by re-introducing them into the final models one at a time. Sire and Dam were also included as a random effect in mixed effect multi level models to account for any potential associations between genetics and performance.

The analyses were designed to test the following hypotheses:

H1: Horses that sustained one or more fracture during their early career were likely to perform less well during their subsequent racing career.

H2: Horses that sustained one or more limb fracture during their early career were likely to perform less well during their subsequent racing career.

H3: Horses that sustained one or more fracture **and** an MSK during their early career were likely to perform less well during their subsequent racing career

3 Results

3.1 Data

The original dataset contained 365,334 observations for 3,988 individual horses recorded between 2000 and 2006, inclusive. Individual horse ID, date of birth, sex, horse type, procedure categories and dates, horse location and results of procedures were included. The frequency of different records for the 25 procedure categories are provided in Table 2.

Table 2. Procedure categories and occurrence in dataset.

Procedure Category	*n*
Medical	43539
Growth Measurements	42365
Movements	38634
Blacksmith	24965
Worming	21270
Ratings[6]	20800
Flu & Tet vaccinations	6534
Examine	6464
Mare Reproductive	5835
EHV 1,4 Vaccinations	4990
Veterinary	3949
X-ray	3929
Misc. vaccinations	2457
Flu & EHV 1,4 vaccinations	1944
Routine Health Injections	1397
Horse Transfer Category	624
Exercise Management	437
Surgery	329
Farriery	202
Veterinary Procedures	114
Stallion Reproductive	13
Flu Vaccinations	2
Miscellaneous	1
Reproductive	1

Three thousand nine hundred and eighty eight horses were initially classified by their most recent gender status as follows: 2,077 mares (females 5 years old and over), 877 colts, 866 fillies, 90 geldings, 71 horses (males 5 years old and over), and seven horses did not have a gender recorded. These horses were also classified by their most recent age or type of horse status as follows: 2,002 broodmares, 737 three year olds, 421 two year olds, 235 four years old and over, 203 yearlings, 183 foals, 81 foster mare foals, 58 foster mares, 25 stallions, 17

[6] Rating given to foal *post partum* and at other stages during development taking into account conformation and appearance.

horses in training (category that was not used after the late nineties), 10 teaser stallions, 15 retired mares and 1 colt (that was misclassified).

In order to include only horses owned by the breeding operation all horses classified as foster mares, teasers and horses not owned by the stud were removed from the dataset. Thus only the broodmares, three year olds, two year olds, four years old and over, yearlings, foals and stallions were retained in the dataset for further analysis.

3.1.1 Cohort selection

For the purpose of the initial part of the study only foals born between the years 2000 and 2006, inclusive, were included. All animals that were not born within this time period, such as older mares and stallions, were removed from the dataset. This left 1369 younger horses in the dataset which included 621 Colts, 596 fillies, 61 geldings, 22 horses (defined as males 5 years old and over) and 69 mares (defined as female horses over 5 years old and over). Each horse was also described by their final status within the dataset (based on their last entry while still under ownership of the stud). At the end of 2006, there were 442 three year olds, 384 two year olds, 200 yearlings, 180 foals, 91 four years old and over, 64 broodmares and 8 stallions. These horses had an average of 168 procedures recorded, with the minimum number being one and the maximum 720.

3.1.2 Content Analysis: Identified veterinary problems

After five runs through the content analysis procedure and subsequent dictionary changes, 972 (71%) horses were identified as having had at least one veterinary problem between 2000 and 2006, inclusive (ie within the period covered by the dataset). A large amount of the work was done manually, mainly to discard irrelevant records before further analysis. All records for the remaining 397 horses that were not identified as having sustained a veterinary problem through content analysis were examined in order to confirm that they should not be included in any of the 13 veterinary categories. During this procedure 85 individuals were found to have limited or incomplete records and were therefore excluded from the rest of the analysis. Healthy horses were defined as those animals that did not have any veterinary problems covered in our categorisation dictionary but were clearly present on the stud as their records were regularly updated with movement information, vaccinations and routine screenings, etc. In contrast, those with limited records were horses that had just one or two records in the dataset with information regarding routine examinations or procedures being absent.

Individual horses could fall into more than one category if they sustained more than one type of injury, as defined by the 13 veterinary categories. A large proportion of horses (674; 49.23%) were included in the musculoskeletal injury or disease (excluding fractures) (MSK) category (table 3). Fracture (266; 19.43%) and respiratory (223; 16.29%) categories were the next two most common veterinary categories.

Table 3. Number of horses that fell into each veterinary category.

Category	*N (1369)*	*% of whole cohort (1369) (95% CI)*
MSK	674	49.2 (46.6 – 51.9)
Fracture	266	19.4 (17.4 – 21.6)
Respiratory	223	16.93 (14.4 – 18.3)
Infection	216	15.8 (13.9 – 17.8)
Ophthalmic	114	8.3 (7.0 – 9.9)
Gastrointestinal	141	10.3 (8.8 – 12.0)
Reproductive – Foal	83	6.1 (4.9 – 7.5)
Fore Limb Lameness	68	5.0 (3.9 – 6.2)
Hind Limb Lameness	58	4.2 (3.3 – 5.4)
Dermatological	39	2.9 (2.1 – 3.9)
Reproductive -Female	36	2.6 (1.9 – 3.6)
Neurological	27	2.0 (1.4 – 2.9)
Reproductive - Male	10	0.7 (0.4 – 1.3)
No veterinary problem	312	29.0 (20.6 – 25.1)
Horses with missing data	85	6.2 (5.0 – 7.6)

3.1.3 Final Status of cohort

In total, 1144 (84%) horses of the original 1369 were allocated a final status by the stud within the dataset (table 4). These included horses that had not been included in one of the veterinary categories. The 225 horses that were not allocated a final status had missing, limited, incomplete records within the dataset or it was not possible to determine the final status from the records provided.

Table 4. Final status of the 2000 to 2006 cohort.

Status	*Total (n=1369)*	*%*
Still a Foal	54	3.9
Deceased	84	6.1
Sold as Foal	6	0.4
Sold as 1yo	9	0.7
Sold as 2yo	144	10.5
Sold as 3yo	107	7.8
Sold as 4yo	7	0.5
Into training and sold as 2yo	48	3.5
Into training and sold as 3yo	275	20.1
Into training and sold as 4yo	45	3.3
Into training and sold as 5yo	7	0.5
Into training and sold as 6yo	4	0.3
1yo in pre training	70	5.1
2yo in pre training	27	2.0
3yo in pre training	0	0.0
1yo in training	34	2.5
2yo in training	77	5.6
3yo in training	8	0.6
4yo in training	3	0.2
Broodmare	98	7.2
Stallion	4	0.3
Gifted	18	1.3
Foal share	15	1.1
No status identified	225	16.4
Total	1369	100.0

3.1.3.1 Veterinary problems and the final status of cohort

Of the 972 horses identified as having a veterinary problem, 903 (93%) were identified with a final status. All 13 veterinary problem groups are shown with their “final status” in table 5, showing that the largest groups were MSK (709), fracture (285) and respiratory (262). Sixty nine horses that had been identified with a veterinary problem could not be allocated with a final status due to limited or incomplete records.

Table 5. The number and percentage of all horses with at least one veterinary problem that resulted in them being categorised into broad classifications of veterinary problems. The number in each category is also classified by final status

	Total (n=903. Excluding those with 'no veterinary problem')	*%* [7]	*HD**	*HS**	*TS**	*PT**	*HT**	*BROOD-MARE*	*STALLION*	*GIFTED*	*FOAL SHARE*
Dermatological	48	3.5	2	12	13	2	3	2	0	1	0
Forelimb Lameness	78	5.7	3	20	19	3	2	10	0	2	0
Fracture	285	20.8	21	71	71	5	14	28	1	3	0
Gastrointestinal	161	11.8	18	31	41	5	12	13	0	0	0
Hindlimb Lameness	67	4.9	4	14	18	2	5	5	0	1	0
Infection	195	14.2	7	42	49	7	12	26	1	2	0
MSK	709	51.8	36	176	187	19	40	54	2	7	1
Neurological	26	1.9	12	5	3	0	2	0	0	1	0
Ophthalmic	117	8.5	3	25	30	2	11	15	0	1	0
Reproductive - Female	34	2.5	0	0	0	1	0	33	0	0	0
Reproductive - Male	71	5.2	4	15	15	3	8	7	0	0	4
Reproductive - Foal	16	1.2	0	1	7	0	0	0	0	0	1
Respiratory	262	19.1	9	60	83	2	7	16	0	2	0
No Veterinary Problem	282	20.6	6	33	192	2	36	5	0	6	2

***HD - horse deceased; HS - horse sold prior to entering training; TS - horse sold after entering training; PT - horse still in pre training at the end of the dataset period; HT - horse still in training at the end of the dataset period**

3.2 Cohort Selection: 2000-2004

Only horses born between 2000 and 2004 that had the chance to reach training age within the dataset period were included in this analysis.

3.2.1 Data

1044 horses were born between 2000 and 2004, inclusive, and were classified by their most recent gender status as follows; 462 colts, 430 fillies, 61 geldings, 22 horses (males 5 years old and over) and 69 mares (females 5 years old and over). These horses were also classified by their most recent age or type of horse

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[7] **Percentage of horses identified with a final status (n=903)**

status as follows; 442 three year olds, 384 two year olds, 91 four years old and over, 64 broodmares, 35 foals, 20 yearlings, and 8 stallions. These horses underwent a mean of 183 procedures, with the minimum amount being 1 and the maximum 720.

3.2.2 Content Analysis: Identified veterinary problems

Veterinary problems that were identified in the 2000 to 2004 cohort are summarised in table 6. Seven hundred and seventeen horses (68.7%) were identified as sustaining a problem. MSK, fracture and respiratory problems represented the largest groups with 522 (50%), 214 (21%) and 179 (17%) horses respectively. Table 6 also shows the number of affected horses born in each of the years from 2000 to 2004. Horses could appear in more than one veterinary category but were only accounted for once in each category. In every birth cohort MSK was the most common veterinary problem. However, there does appear to be some degree of variation on the prevalence of different problems, for example, the proportion of horses identified with an MSK that were born in 2001 (93.1%) is considerably higher than those horse born in 2000, 2002, 2003 and 2004 (72.9%, 63.4%, 70.7% and 61.2% respectively). Similarly, the proportion of horses identified as sustaining a fracture or respiratory problem that were born in 2000 (50% and 43.8%, respectively) was higher than in all other years (table 6).

Table 6. The number and % (95% CI) of affected horses born in each of the years from 2000 to 2004, inclusive

	total foals	*% of cohort (1044) (95% CI)*	*Year of Birth* 2000 (195)	% [8] (95% CI)	2001 (202)	% (95% CI)	2002 (209)	% (95% CI)	2003 (207)	% (95% CI)	2004 (231)	% (95% CI)
Total number of horses sustaining problem	717	68.7 (65.8 - 71.4)	144	73.8 (67.3-79.5)	159	78.7 (72.6-83.8)	142	67.9 (61.3-73.9)	133	64.3 (57.5-70.5)	139	60.2 (53.7-66.3)
MSK	522	50 (47.0 - 53.0)	105	3.8 (46.8-60.7)	148	73.3 (66.8-78.9)	90	43.1 (36.5-49.8)	94	45.4 (38.8-52.2)	85	36.8 (30.8-43.2)
Fracture	214	20.5 (18.2 - 23.1)	72	36.9 (30.5-43.9)	45	22.3 (17.1-28.5)	45	21.5 (16.5-27.6)	22	10.6 (7.1-15.6)	30	13.0 (9.3-17.9)
Respiratory	179	17.2 (15.0 - 19.6)	63	32.3 (26.1-39.2)	37	18.3 (13.6-24.2)	24	11.5 (7.8-16.5)	40	19.3 (14.5-25.2)	15	6.5 (4.0-10.4)
Infection	146	14 (12.0 - 16.2)	33	16.9 (12.3-22.8)	23	11.4 (7.7-16.5)	27	12.9 (9.0-18.1)	30	14.5 (10.3-19.9)	33	14.3 (10.4-19.4)
Gastrointestinal	120	11.5 (9.7 - 13.6)	22	11.3 (7.57-16.5)	30	14.9 (10.6-20.4)	31	14.8 (10.7-20.3)	11	5.3 (3.0-9.3)	26	11.3 (7.8-16.0)
Ophthalmic	87	8.3 (6.8 - 10.2)	17	8.7 (5.5-13.5)	18	8.9 (5.7-13.6)	16	7.7 (4.8-12.1)	13	6.3 (3.7-10.4)	23	10.0 (6.7-14.5)
Forelimb lameness	59	5.7 (4.4 - 7.2)	16	8.2 (5.1-12.9)	15	7.4 (4.6-11.9)	19	9.1 (5.9-13.8)	1	0.5 (0.1-2.7)	8	3.5 (1.8-6.7)
Reproductive - foal	56	5.4 (4.2 - 7.2)	13	6.7 (3.9-11.1)	7	3.5 (1.7-7.0)	9	4.3 (2.3-8.0)	14	6.8 (4.1-11.0)	13	5.6 (3.3-9.4)
Hindlimb lameness	49	4.7 (3.6 - 6.2)	14	7.2 (4.3-11.7)	14	6.9 (4.2-11.3)	11	5.3 (3.0-9.2)	4	1.9 (0.8-4.9)	6	2.6 (1.2-5.5)
Dermatological	35	3.4 (2.4 - 4.6)	10	5.1 (2.8-9.2)	8	4.0 (2.0-7.6)	9	4.3 (2.3-8.0)	4	1.9 (0.8-4.9)	4	1.7 (0.7-4.4)
Reproductive - female	34	3.3 (2.3 - 4.5)	15	7.7 (4.7-12.3)	15	7.4 (4.6-11.9)	3	1.4 (0.5-4.1)	0	0.0 (0.0-0.0)	1	0.4 (0.1-2.4)
Neurological	23	2.2 (1.5 - 3.3)	4	2.1 (0.8-5.2)	5	2.5 (1.1-5.7)	6	2.9 (1.3-6.1)	4	1.9 (0.8-4.9)	4	1.7 (0.7-4.4)
Reproductive - male	9	0.9 (0.5 - 1.6)	4	2.1 (0.8-5.2)	1	0.5 (0.1-2.8)	2	1.0 (0.-3.4)	0	0.0 (0.0-0.0)	2	0.9 (0.2-3.1)
No Veterinary Problem	257	24.6 (22.1 - 27.3)	41	21 (15.9-27.3)	32	15.8 (11.5-21.5)	52	24.9 (19.5-31.2)	58	28.0 (22.3-34.5)	74	32.0 (26.4-38.3)
Horses with missing data	70	6.7 (5.3 - 8.4)	10	5.1 (2.8-9.2)	11	5.4 (3.1-9.5)	15	7.2 (4.4-11.5)	16	7.7 (4.8-12.2)	18	7.8 (5.0-12.0)

[8] Percentage of birth year cohort

3.2.3 Final Status

A number of horses (327) were identified by the software as not having sustained a veterinary problem while under ownership of the stud. Seventy of these individuals were found to have limited or incomplete records, or provided no detail relating to veterinary problems within the dataset (Table 6).

Nine hundred and seventy four (93.3%) horses were identified with a final status. A summary of those identified is shown in figure 1. Of the complete 2000 to 2004 cohort for which it was possible to identify a final status, 61% (590) of the horses successfully entered full training of which 17% (102) were still in full training at the end of the dataset period. Three hundred and eighty four (39%) horses were not in training at the end of the dataset period. Of these, sixteen percent (61/384) of horses failed to reach training age, of which 23 died before weaning, and 38 died between weaning and full training. Two hundred and sixty two (68%) of horses were sold before reaching training age and 27 (7%) of horses were still in pre training at the end of the dataset period.

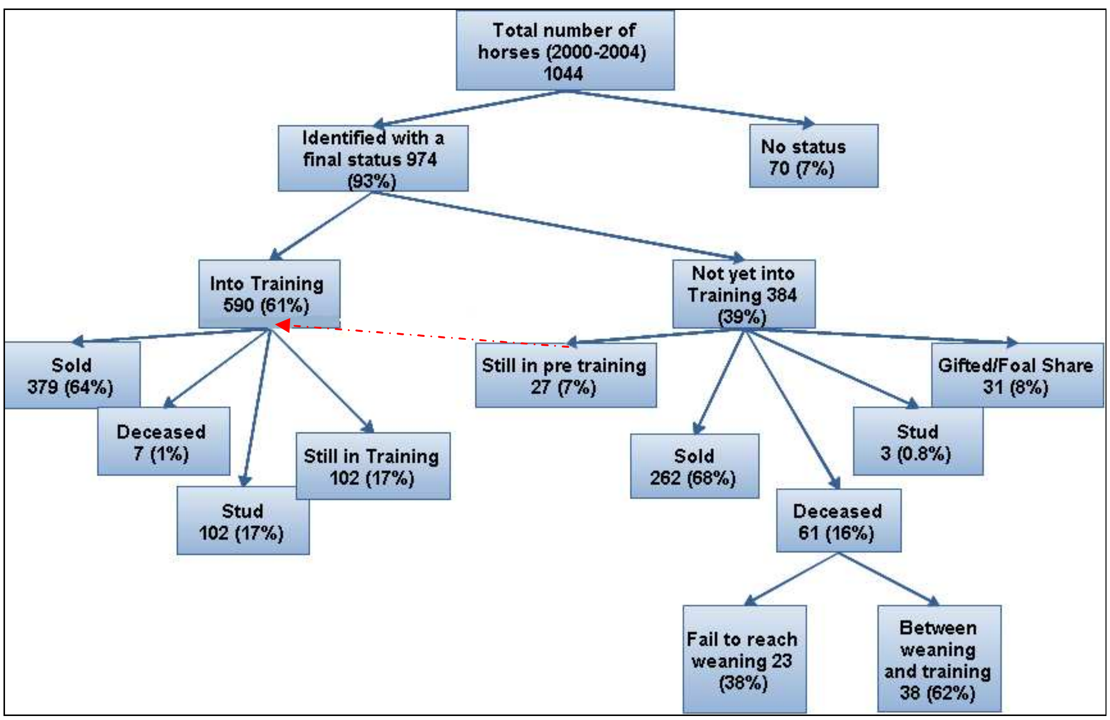

Figure 1. Flow diagram showing the final status of all horses in the cohort. The dashed arrow indicates that although horses may still have been in pre training at the time of the study, they may have entered training at a later date under ownership of the stud. Percentages attributed to each part of the flow diagram are of the level above and not of the whole of the original cohort.

3.2.4 Pre Training Veterinary Problems

In total 326 horses with at least one MSK, 103 horses with at least one fracture, and 91 horses with at least one respiratory problem were identified prior to horses reaching training age. Fifty-seven percent (185) of horses that sustained an MSK, prior to going into training, successfully entered training under ownership of the breeding operation. Of those that sustained a fracture prior to reaching training age, 37.9% of horses (39) successfully entered training under ownership of the breeding operation, and 47.3% of horses (43) that were identified with a respiratory problem entered training under ownership of the breeding operation. A summary of the final status of all horses that sustained at least one MSK, fracture or respiratory problem before entering training is given in table 7.

Table 7. Three largest veterinary problem groups showing their final status within the dataset.

		Musculoskeletal				*Respiratory*	
		Fracture		MSK			
			%		%		%
	n	103	9.9	326	31.2	91	8.7
Into Training		**39**	**37.9**	**185**	**56.7**	**43**	**47.3**
	Sold	25	64.1	121	65.4	34	79.1
	Stud	7	17.9	34	18.4	5	11.6
	Deceased	0	0.0	5	2.7	0	0.0
	Still in training	7	17.9	25	13.5	4	9.3
Not into Training		**64**	**62.1**	**141**	**43.3**	**48**	**52.7**
	Sold	45	70.3	102	72.3	42	87.5
	Deceased	13	20.3	21	14.9	4	8.3
	Gifted	1	1.6	7	5.0	1	2.1
	Stud	2	3.1	2	1.4	0	0.0
	Pre training	3	4.7	9	6.4	1	2.1

3.2.4.1 Musculoskeletal injury or disease (excluding fractures)

As described in chapter 2 this category described numerous veterinary conditions associated with the joints and soft tissues of the musculoskeletal system. Fifty seven percent (185) of the 326 horses within this veterinary category entered full training at some point while still under ownership of the breeding operation. As a group, this percentage indicates that although MSK represented the most common veterinary problem, horses that sustain one of these problems were 1.2 (95%CI = 0.98-1.40; p-value= 0.10) times more likely not to enter training. In other words horses with these problems were no more or less likely to enter training than the unaffected cohort i.e. all horses that had not sustained an MSK.

Osteochondrosis dissecans (OCD) was the most frequently diagnosed MSK accounting for 38% (124) of problems within this category. Of horses that were diagnosed with OCD 61.3% (76) entered training successfully under ownership of the breeding operation, indicating that horses with OCD were as likely (Relative Risk = 0.97 (95%CI = 0.69-1.36); p-value= 0.94) to enter training as the unaffected cohort. Similarly, those that were identified with sesamoiditis (31%; 100) were as likely (Relative Risk = 0.83 (95%CI = 0.56-1.22); p-value= 0.40) to enter training as the unaffected cohort. In contrast, of the 28 suspensory ligament cases, representing 8.6% of MSK conditions, only 28.6% (8) of horses continued into full training. Horses with suspensory ligament injury were 4.03 times (95%CI = 1.80-9.01) more likely not to enter training than the unaffected cohort (p-value <0.001). None of the other frequently observed sub categories: conformational abnormalities, tendon problems, and bone cysts, were significantly associated with the likelihood of entering training under ownership of the breeding operation (table 8).

Table 8 - Univariate chi squared test to show associations between specific MSK conditions and the likelihood of entering training under the ownership of the breeding operation. (P-values marked '*' are Fisher exact 2 tailed values, all others are Yates corrected p-values). RR= Relative Risk, 95% CI = 95% Confidence Interval.

Condition	*Total*	*Training (n=590)*	*Not Training (n=384)*	*Chi sq (Yates corrected)*	*P-value*	*RR*	*95% CI*
MSK - ALL	326	185	141	2.77	0.10	1.17	0.98-1.40
Osteochondrosis dissecans	124	76	48	0.01	0.94	0.97	0.69-1.36
Sesamoiditis	100	65	35	0.72	0.40	0.83	0.56-1.22
Conformational abnormalities	33	16	17	1.60	0.21	1.63	0.83-3.19
Suspensory ligament	29	8	21	12.23	<0.001	4.03	1.80-9.01
Tendon pathology	20	9	11	1.46	0.23	1.88	0.79-4.49
Bone cyst	13	6	7	0.62	0.43	1.79	0.61-5.29
Numerous at x-ray screening	12	8	4	0.02	0.77*	0.77	0.23-2.53
Arthritis	6	5	1	0.53	0.41*	0.31	0.04-2.62
Periosteal reaction	5	4	1	0.19	0.65*	0.38	0.04-3.42
Check ligament (desmotomy)	5	4	1	0.19	0.65*	0.38	0.04-3.42
Joint flush/septic arthritis	5	2	3	0.24	0.39*	2.30	0.39-13.73
Splint exostosis	4	1	3	0.88	0.31*	4.59	0.48-43.92
Spinal condition	3	0	3	2.43	0.06*	na	na
epiphysitis	4	3	1	0.01	1.0*	0.51	0.05-4.91
sequestrum	3	3	0	0.65	0.28*	na	na
Pinfire tendons	3	0	3	2.43	0.06*	na	na
Upward fixation of the patella	1	1	0	0.05	1.0*	na	na
immature joints	1	0	1	0.05	0.40*	na	na
muscle wastage	1	0	1	0.05	0.40*	na	na
laminitis	1	0	1	0.05	0.40*	na	na
stone bruise/lysis	1	1	0	0.05	1.0*	na	na
pedal bone abnormalities	1	1	0	0.05	1.0*	na	na
bursitis	1	1	0	0.05	1.0*	na	na
physitis	1	1	0	0.05	1.0*	na	na
saggital ridge abnormalities	1	1	0	0.05	1.0*	na	na

3.2.4.2 Fracture

One hundred and three horses were identified as having sustained a fracture pre training accounting for 9.9% of the 2000 to 2004 cohort. Eleven of the fractures resulted in fatality, or euthanasia and the anatomical location of these 11 fractures is provided in table 9.

Table 9. Anatomical location of fractures resulting in fatality or euthanasia

Fracture Location	**Number**
Metacarpal/tarsal III	1
Metacarpal Phalangeal	1
Femur	1
Humerus	2
Scapula	1
Cervical Vertebrae	2
Proximal Phalanx	1
Tibia	2
Total	11

Of the 103 horses identified in this category 37.9% (39) entered full training while still under ownership of the stud. Horses that sustained a fracture were significantly less likely (p-value <0.001) to enter training than the rest of the unaffected cohort. Horses in this group were 2.52 times (95%CI = 1.73-3.68) more likely not to go into training than the unaffected cohort; i.e. all horses that had not sustained a fracture (table 10).

The anatomical locations of the 92 non fatal fractures are described in table 10. Of these horses, 42.4% (39) entered training while under the ownership of the breeding operation. These horses were 2.09 times (95%CI = 1.41-3.09) more likely not to enter training than the unaffected cohort (p-value <0.001). The proximal sesamoid bones were the most frequently observed fracture location accounting for 31.5% (29) of all non fatal fractures. Forty five percent (13) of horses with proximal sesamoid fractures entered full training under ownership of the breeding operation. There was a weak association between fracture of the proximal sesamoid bones and the likelihood that affected horses would enter training. Such horses were 1.89 times (95%CI = 0.92-3.89) more likely not to enter training than the unaffected cohort (p-value = 0.12).

Fractures of the second and fourth metacarpal/tarsal bones and fractures described as affecting the metacarpo/tarso-phalangeal joint were the next most common anatomical locations (12 at each site). Neither fracture site was significantly associated with the likelihood that a horse would enter training (table 10).

Fractures of the tarsus and distal phalanx were also common, accounting for 9 (10% of non-fatal fractures) and 10 (11% of non-fatal fractures). Horses that sustained fractures of the distal phalanx were weakly associated with an increased likelihood of not entering training while under the ownership of the breeding operation (RR= 3.59; 95%CI = 0.93-13.78; p-value= 0.06). There was also a weak association between fracture of the third metacarpal or metatarsal and the likelihood of entering training under ownership of the breeding operation (RR= 3.04, 95%CI; p-value= 0.08).

Table 10 - Univariate chi squared test to show association between horses that sustain fractures at specific sites and the rest of the cohort looking at whether they make it into training or not. (P-values marked '*' are Fisher exact 2 tailed values, all others are Yates corrected p-values). RR= Relative Risk, 95% CI = 95% Confidence Interval.

Anatomical Site	*Total*	*Training (n=590)*	*Not Training (n=384)*	*Chi sq (Yates corrected)*	*P -value*	*RR*	*95% CI*
ALL	103	39	64	23.82	<0.001	2.52	1.73-3.68
ALL NON FATAL	92	39	53	13.24	<0.001	2.09	1.41-3.09
Proximal sesamoid	29	13	16	2.46	0.12	1.89	0.92-3.89
Metacarpal/tarsal II/IV	12	8	4	0.19	0.77*	0.91	0.61-1.36
Metacarpo/tarso phalangeal	12	6	6	0.21	0.56*	1.54	0.50-4.73
Distal phalanx	10	3	7	2.77	0.06*	3.59	0.93-13.78
Tarsus	9	4	5	0.43	0.33*	1.92	0.52-7.11
Metacarpal/tarsal III	5	1	4	1.97	0.08*	6.15	0.69-54.8
Proximal phalanx	5	4	1	0.19	0.65*	0.38	0.04-3.42
Distal sesamoid	3	1	2	0.14	0.57*	3.07	0.28-33.8
Carpus	2	0	2	1.06	0.16*	na	na
Rib	2	2	0	0.17	0.52*	na	Na
Nasal bone	2	0	2	1.06	0.16*	na	Na
Pelvis	2	1	1	0.17	1.0*	1.54	0.10-24.5
Scapula	1	0	1	0.05	0.39*	na	na
Humerus	1	0	1	0.05	0.39*	na	na
Tibia	1	1	0	0.05	1.0*	na	na
Radius	1	0	1	0.05	0.39*	na	na
Mandible	1	1	0	0.05	1.0*	na	na
Cranium	1	0	1	0.05	0.39*	na	Na

3.2.4.3 Respiratory

As described in chapter two, veterinary respiratory problems involved both upper and lower respiratory tract abnormalities and included acquired, as well as developmental disorders. Of the 91 horses that were identified as having a respiratory problem, 47.3% (43) entered full training under ownership of the breeding operation. Horses identified with a respiratory problem were 1.7 times (p-value = 0.008; 95%CI = 1.16-2.54) more likely not to go into training than the unaffected cohort; i.e. all horses that had not been diagnosed with a respiratory problem (table 11).

The 68 horses with upper respiratory tract problems are described in table 11. Of these horses 42.7% (29) entered training under ownership of the breeding operation. These horses were 2.07 times (95%CI = 1.30-3.28) more likely not to go into training than the unaffected cohort (p-value= 0.003). Fifty one lower respiratory tract problems were identified and are described in table 11. Of these horses 52.9% (27) entered training under ownership of the breeding operation.

Disorders of the larynx were most frequently observed accounting for 54.4% (37) of all upper respiratory tract problems. The majority of laryngeal conditions were diagnosed as recurrent laryngeal neuropathy (52.9%; 36) and one horse was diagnosed with an immature larynx. Thirty five percent (13) of horses with a laryngeal problem entered full training while under ownership of the breeding operation. There was a strong association between laryngeal problems and the likelihood that affected horses would enter training. Such horses were 2.8 times (95%CI = 1.46-5.50) more likely not to enter training than the unaffected cohort (p-value= 0.002). Palatal instability was the next most commonly observed upper respiratory problem affecting for 29.4% (20) of horses. Forty five percent of horses with palatal instability entered full training under ownership of the breeding operation but this disorder was not significantly associated with the likelihood that a horse would enter training (table 11).

Nasal discharge was the most frequently observed lower respiratory tract problem affecting 62.7% (32) of horses. Fifty percent (16) of horses identified with nasal discharge entered full training under ownership of the breeding operation. There was no statistically significant association between nasal discharge and the likelihood that affected horses would enter training ((p-value= 0.29) (table 11)). Coughing was the next most commonly observed lower respiratory tract problem affecting 33.3% (17). Fifty three percent (9) of horses identified with this problem entered full training under ownership of the breeding operation and there was no association between coughing and the likelihood that affected horses would enter training ((p-value= 0.69) (table 11)).

Table 11 - Univariate chi squared test to show association between horses identified with specific respiratory conditions and the rest of the cohort, looking at whether they make it into training or not. (P-values marked '*' are Fisher exact 2 tailed values, all others are Yates corrected p-values). RR= Relative Risk, 95% CI = 95% Confidence Interval.

Condition	*Total*	*training (n=590)*	*not training (n=384)*	*Chi sq (Yates corrected)*	*P-value*	*RR*	*95% CI*
ALL	91	43	48	6.86	0.008	1.72	1.16-2.54
ALL UPPER	68	29	39	9.05	0.003	2.07	1.30-3.28
Larynx	37	13	24	9.34	0.002	2.84	1.46-5.50
Palate instability	20	9	11	1.46	0.23	1.88	0.79-4.49
Pharyngeal lymphoid hyperplasia	2	2	0	0.17	0.52*	na	na
Upper respiratory tract infection	2	1	1	0.17	1.00*	1.54	0.10-24. 5
Pharyngitis	2	1	1	0.17	1.00*	1.54	0.10-24. 5
Rostral displacement of the paltine arch	1	0	1	0.05	0.39*	na	na
Sinusitis	1	1	0	0.05	1.00*	na	na
Nasal bone fracture	1	1	0	0.05	1.00*	na	na
Guttural pouch abscess	1	0	1	0.05	0.39*	na	na
Guttural pouch mycosis	1	1	0	0.05	1.00*	na	na
ALL LOWER	51	27	24	1.0	0.32	1.37	0.80-2.33
Nasal discharge	32	16	16	1.13	0.29	1.54	0.78-3.04
Cough	17	9	8	0.16	0.69	1.37	0.53-3.51
Bronchitis	1	1	0	0.05	1.00*	na	na
Ventipulmin lesion (lesion formed after prolonged use of ventipulmin)	1	1	0	0.05	1.00*	na	na

3.3 The relationship of veterinary problems and performance

In total, 1004 named horses were identified from all horses born between 2000 and 2004, inclusive. Horses are only officially named when registered for racing prior to entering training. Of these, 690 (68.7%) were found to have a performance history (i.e. raced at least once) within the Racing Post online dataset. Of these, 75.7% (522/690) raced while still under the ownership of the breeding operation, 122 were sold by the breeding operation before racing, 14 were still in pre-training at the end of the dataset period (therefore their final status with the breeding operation was unknown), and 32 were from the group with no final status identified. Performance data were collected from the beginning of each horse's racing career until mid May 2009. At this time the oldest horses in the cohort would have been nine years old and the youngest five years old. The 690 horses with race records had a mean of 11(median = 7) life time starts and (ranging from one to 90 starts) with a mean of 1.5 (median = 1) wins (ranging from zero to 15 wins) and 2.5 (median = 2) 2nd or 3rd places (ranging from zero to 28 places). Prize money accumulated during this time period ranged from £0 to £1,074,965 (mean = £32,046. median = £7282). The highest amount earned through winning races was £1,070,413 (range = £0 - £1,070,413, mean = £19,040, median = 4071). Maximum Racing Post Ratings (RPR) ranged from four to 157 and maximum Official Ratings (OR) ranged from 27 to 145. Mean RPRs and mean ORs ranged from four to 143 and 27 to 137, respectively. Five veterinary categories were investigated; MSK, fracture, respiratory, limb fracture, and those horses who sustained both a fracture **and** an MSK.

3.3.1 Musculoskeletal injury or disease (excluding fractures) and performance

Two hundred and five (62.9%) of the original 326 horses that had sustained at least one MSK were identified with a performance history. These horses had a mean of 11.2 (median = 7) life time starts during their racing career, ranging from one to 90 starts, with a mean of 1.5 wins (median = 1), ranging from zero to 15, and 2.5 places, ranging from zero to 23. Prize money accumulated within this group, ranged from £0 to £495,759 (mean = £24,200, median = £6712), with £473,166 being the highest amount won by winning races by an individual within the group. Maximum RPRs ranged from four to 153 and maximum ORs ranged from 40 to 144. Mean RPRs and mean ORs ranged from seven to 143 and 39 to 137, respectively.

3.3.2 Fracture and performance

Fifty two (50.5%) of the original 103 horses that had sustained at least one fracture were identified with a performance history. These horses had a mean of 11.9 (median = 5.5) starts during their racing career, ranging from one to 90, with a mean of 1.3 (median = 1) wins, ranging from zero to 15, and 2.3 (median = 1) places, ranging from zero to 13. Prize money accumulated by horses within this group ranged from £0 to £183,782 (mean = £18,229, median = £6568) with £115,047 being the highest amount won by winning races by an individual within the group. Maximum RPRs ranged from 31 to 121 and maximum ORs ranged from 30 to 99. Mean RPRs and mean ORs ranged from 31 to 121 and 30 to 99, respectively.

3.3.3 Respiratory and performance

Fifty five (60.4%) of the original 91 horses that has sustained at least one respiratory problem were identified with a performance history. These horses had a mean of 13.8 (median = 8) starts, ranging from one to 55, with a mean of 1.8 (median = 1) wins, ranging from zero to nine, and 3.4 (median = 2) places, ranging from zero to 22. Prize money accumulated by these horses ranged from £0 to £1,074,965 (mean = £42,238, median = £8071) with £1,070,413 being the highest amount won by winning races by an individual within the group. Maximum RPRs ranged from 14 to 133 and maximum ORs ranged from 45 to 144. Mean RPRs and mean ORs ranged from 27 to 133 and 45 to 137, respectively.

3.3.4 Limb Fracture and performance

Forty eight (47%) horses were identified as having sustained a fracture of the limb within the fracture group and had a performance history. These horses had a mean of 11.9 (median = 6) starts during their racing career, ranging from one to 90, with a mean of 1.4 (median = 1) wins, ranging from zero to 15, and 2.4 (median = 1) places, ranging from zero to 13. Prize money accumulated by horses within this group ranged from £0 to £183,782 (mean = £19,376, median = £6602) with £115,047 being the highest amount won by winning races by an individual within the group. Maximum RPRs ranged from 31 to 121 and maximum ORs ranged from 30 to 99. Mean RPRs and mean ORs ranged from 31 to 121 and 30 to 99, respectively.

3.3.5 Fracture and musculoskeletal disease or injury and performance

Thirty two horses sustained both a fracture **and** an MSK and had a performance history. These horses had a mean of 14 (median = 6) starts during their racing career, ranging from one to 90, with a mean of 1.6 (median = 1) wins, ranging from zero to 15, and 2.7 (median = 1) places, ranging from zero to 13. Prize money accumulated by horses within this group ranged from £0 to £98,724 (mean = £17,290, median = £9697) with £62,767 being the highest amount won by winning races by an individual within the group. Maximum RPRs ranged from 7 to 121 and maximum ORs ranged from 40 to 94. Mean RPRs and mean ORs ranged from 36 to 121 and 40 to 88, respectively.

All racing performance parameters according to specific MSK, fracture, or respiratory problem categories can be found in Appendix 4.

3.3.5.1 Statistical Analysis

Six hundred and fifty eight of the horses with performance data were included for further analysis. The 32 horses with performance data that had no final status identified in the stud dataset were excluded from analyses as it was unclear as to whether a full medical history was available for these horses, due to limited or incomplete records.

Details of data distribution, normality tests, and variance testing can be found in Appendix 2.

The mean, median and range of all performance variables (number of career starts, wins, places, career winnings (£ - money earned from winning races), career earnings (£ - money earned from winning and from being placed), maximum RPR, average RPR, maximum OR and average OR) for different groups of horses are shown in Tables 12-14. The results of Mann-Whitney or two sample T-tests (where appropriate) comparing the groups with and without different veterinary problems prior to entering training are provided in Table 15.

Table 12. Mean, median and range of number of starts, wins and places for horses in each of the five veterinary categories.

Horse Group		*STARTS*			*WINS*			*PLACE*		
	n	**Mean**	**Median**	**Range**	**Mean**	**Median**	**Range**	**Mean**	**Median**	**Range**
No fracture	606	11.2	7.0	1 - 85	1.5	1.0	0 - 10	2.5	2.0	0 - 26
Fracture	52	11.9	5.5	1 - 90	1.3	1.0	0 - 15	2.3	1.0	0 - 13
No Limb Fracture	610	11.2	7.0	1 - 85	1.5	1.0	0 - 10	2.5	2.0	0 - 26
Limb Fracture	48	11.9	6.0	1 - 90	1.4	1.0	0 - 15	2.4	1.0	0 - 13
No MSK	453	11.3	7.0	1 - 72	1.5	1.0	0 - 10	2.5	2.0	0 - 26
MSK	205	11.2	7.0	1 - 90	1.5	1.0	0 - 15	2.5	1.0	0 - 23
No Respiratory Problem	603	11.1	7.0	1 - 90	1.5	1.0	0 - 15	2.4	1.0	0 - 26
Respiratory Problem	55	13.8	8.0	1 - 55	1.8	1.0	0 - 9	3.3	2.0	0 - 22
No Fracture and MSK	626	11.2	7.0	1 - 85	1.5	1.0	0 - 10	2.5	2.0	0 - 26
Fracture and MSK	32	14.0	6.0	1 - 90	1.6	1.0	0 - 15	2.7	1.0	0 - 13

Table 13. Mean, median and range of total winnings (£) and earnings (£) for horses in each of the five veterinary categories.

Horse Group		*WINNINGS (£)*			*EARNINGS (£)*		
	n	**Mean**	**Median**	**Range**	**Mean**	**Median**	**Range**
No fracture	606	19748	4222	0 - 1070413	33232	7369	0 - 1074965
Fracture	52	10792	2188	0 - 115047	18229	6568	0 - 183782
No Limb Fracture	610	19638	4165	0 - 1070413	33043	7331	0 - 1074965
Limb Fracture	48	11441	2851	0 - 115047	19376	6602	0 - 183782
No MSK	453	20576	4127	0 - 1070413	35597	7878	0 - 1074965
MSK	205	15647	3969	0 - 473166	24200	6712	0 - 495759
No Respiratory Problem	603	17876	4056	0 - 603583	31116	7112	0 - 879684
Respiratory Problem	55	31801	4368	0 - 1070413	42238	8071	0 - 1074965
No Fracture and MSK	626	19474	4071	0 - 1070413	32800	7183	0 - 1074965
Fracture and MSK	32	10553	3913	0 - 62767	17290	9697	0 - 98724

Table 14. Mean, median and range of maximum and average Racing Post ratings, and maxium and average Official ratings for horses in each of the five veterinary categories.

Horse Group		*Maximum RPR*			*Average RPR*			*Maximum OR*			*Average OR*		
	n	**Mean**	**Median**	**Range**	**Mean**	**Median**	**Range**	**Mean**	**Median**	**Range**	**Mean**	**Median**	**Range**
No fracture	606	88	89	4 - 121	88	83	4 - 143	83	83	27 - 145	78	79	27 - 137
Fracture	52	82	83	31 - 121	79	81	31 - 121	69	70	30 - 99	66	68	30 - 99
No Limb Fracture	610	88	89	4 - 157	82	82	4 - 143	83	83	27 - 145	78	78	27 - 137
Limb Fracture	48	83	85	31 - 121	80	82	31 - 121	69	70	30 - 99	66	68	30 - 99
No MSK	453	89	90	14 - 157	81	83	4 - 128	82	83	27 - 145	77	77	27 - 125
MSK	205	84	86	4 - 140	82	82	7 - 143	83	80	40 - 144	78	78	39 - 137
No Respiratory Problem	603	87	88	4 - 157	82	85	4 - 135	82	82	27 - 145	77	77	27 - 130
Respiratory Problem	55	87	90	14 - 133	80	80	27 - 143	86	90	45 - 144	81	76	45 - 137
No Fracture and MSK	626	88	88	4 - 157	82	82	4 - 143	82	83	27 - 145	78	78	27 - 137
Fracture and MSK	32	82	85	7 - 121	81	82	36 - 121	70	70	40 - 94	67	68	40 - 88

Table 15 - Comparisons of the performance of horses within five categories of injury/disease problems. All comparisons are made against the whole of the unaffected cohort; i.e. those horses that had not sustained either an MSK, fracture, limb fracture, respiratory, or fracture and MSK. All p-values were derived using the Mann Whitney test apart from those marked '*' which were derived using the 2 sampled t-test.

Veterinary Problem	***STARTS*** *p-value*	***WINS*** *p-value*	***PLACE*** *p-value*	***WINNINGS*** *p-value*	***EARNINGS*** *p-value*	***Max RPR*** *p-value*	***Avg RPR*** *p-value*	***Max OR*** *p-value*	***Avg OR*** *p-value*
Fracture	0.2	0.2	0.3	0.2	0.2	0.1*	0.4*	0.001*	0.001*
Limb Fracture	0.3	0.2	0.5	0.2	0.3	0.2	0.6*	0.002*	0.005*
MSK	1	0.8	1	0.6	0.4	0.03*	0.9	0.6*	0.7
Respiratory Problem	0.4	0.7	0.3	1	0.8	0.9*	0.8*	0.3*	0.4*
Fracture and MSK	0.5	0.6	0.9	0.6	0.8	0.3	0.9*	0.01*	0.01*

RPR: Racing Post rating, OR : Official rating

3.3.5.2 Univariable associations between veterinary problems and measures of perfomance

1. Number of career starts, wins and places.

None of the five different categories of veterinary problems were statistically significantly associated with the number of starts, wins or places achieved by horses during their racing careers.

2. Money earned.

None of the five different categories of veterinary problems were statistically significantly associated with the money earned through wins or with total money earned (through winning or being placed) by horses during their racing careers.

3. Maximum and average career Racing Post rating.

Horses that sustained at least one MSK before entering training were associated with a lower maximum RPR during their racing career (mean = 84.; median = 86; range = 4-140) than horses that did not sustain an MSK before entering training (mean = 89; median = 90; range = 14-157) (p-value = 0.03).

None of the other four categories of veterinary problem were associated with maximum career RPR and none of the five categories of veterinary problem were associated with average career RPR.

4. Maximum and average career official rating.

Horses that sustained at least one fracture before entering training achieved a significantly lower maximum official rating during their racing career (mean = 69; median = 70; range = 30-99) than horses that did not sustain a fracture before entering training (mean = 83; median = 83; range = 27-145) (p-value = 0.001).

Horses that sustained at least one fracture of a limb before entering training achieved a significantly lower maximum official rating during their racing career (mean = 69; median = 70; range = 30-99) than horses that did not sustain a fracture of a limb before entering training (mean = 83; median = 83; range = 27-145) (p-value = 0.002).

Horses that sustained at least one MSK **and** at least one fracture before entering training achieved a significantly lower maximum official rating during their racing career (mean = 70; median = 70; range = 40-94) than horses that did not sustain both an MSK **and** sustain a fracture before entering training (mean = 82; median = 83; range = 27-145) (p-value = 0.01).

Horses that sustained at least one fracture before entering training achieved a significantly lower average official rating during their racing career (mean = 66; median = 68; range = 30-99) than horses that did not sustain a fracture before entering training (mean = 78.; median = 79; range = 27-137) (p-value = 0.001).

Horses that sustained at least one fracture of a limb before entering training achieved a significantly lower average official rating during their racing career (mean = 66; median = 68; range = 30-99) than horses that did not sustain a fracture of the limb before entering training (mean = 78; median = 78; range = 27-137) (p-value = 0.005).

Horses that sustained at least one MSK **and** at least one fracture before entering training achieved a significantly lower average official rating during their racing career (mean = 67; median = 68; range = 40-88) than horses that did not sustain both an MSK **and** a fracture before entering training (mean = 78; median = 78; range = 27-137) (p-value = 0.013).

3.3.5.3 Multivariable generalised linear models

1. Using maximum OR as the outcome, three multivariable linear regression models were produced: a) for horses that sustained at least one fracture, b) for horses that sustained at least one limb fracture, and c) for horses that sustained at one fracture **and** an MSK. Each model included two explanatory variables; injury type and gender (table 16).

1a. Horses that sustained at least one fracture early in their career had an expected maximum OR 14.3 units lower than those horses that did not sustain a fracture prior to entering full training (p value = 0.002). Female horses had an expected maximum OR 10.3 units lower than male horses (p value <0.001).

1b. Horses that sustained at least one limb fracture early in their career had an expected maximum OR 14.4 units lower than those horses that did not sustain a limb fracture prior to entering full training (p value = 0.003). Female horses had an expected maximum OR 10.4 units lower than male horses (p value <0.001).

1c. Horses who sustained at least one fracture **and** at least one MSK early in their career had an expected maximum OR 14.0 units lower than those horses that did not sustain both a fracture **and** an MSK prior to entering full training (p value = 0.021). Female horses had an expected maximum OR 10.4 units lower than male horses (p value <0.001).

2. Using average OR as the outcome, three multivariable linear regression models were produced: a) for horses that sustained at least one fracture, b) for horses that sustained at least one limb fracture, and c) for horses that sustained at least one fracture **and** an MSK. Each model included two explanatory variables; injury type and gender (table 16).

2a. Horses that sustained at least one fracture early in their career had an expected average OR 12.6 units lower than those horses that did not sustain a fracture prior to entering full training (p value = 0.003). Female horses had an expected average OR 4.6 units lower than male horses (p value <0.027).

2b. Horses that sustained at least one limb fracture early in their career had an expected average OR 12.0 units lower than those horses that did not sustain a fracture prior to entering full training (p value = 0.007). Female horses had an expected average OR 4.6 units lower than male horses (p value <0.026).

2c. Horses who sustained at least one fracture **and** at least one MSK early in their career had an expected average OR 11.5 units lower than those horses that did not sustain both a fracture **and** an MSK prior to entering full training (p value = 0.043). Female horses had an expected average OR 4.7 units lower than male horses (p value <0.025).

Table 16. Mulivariable general linear models produced for two response variables: 1. Maximum Official Rating, and 2. Average Official Rating. For each response variable three models were produced showing the association between different injury categories and performance. (SE = Standard Error)

Response variable	Explanatory variable	Coefficient	SE	P-value
1. Maximum Official Rating	a. Fracture before entering full training			
	No (reference)	-		-
	Yes	-14.3	4.5	0.002
	Gender			
	Male (reference)	-		-
	Female	-10.3	2.2	<0.001
	b. Limb fracture before entering full training			
	No (reference)	-		-
	Yes	-14.4	4.7	0.003
	Gender			
	Male (reference)	-		-
	Female	-10.4	2.2	<0.001
	c. Fracture **and** MSK before entering full training			
	No (reference)	-		-
	Yes	-14.0	6.0	0.021
	Gender			
	Male (reference)	-		-
	Female	-10.4	2.2	<0.001
2. Average Official Rating	a. Fracture before entering full training			
	No (reference)	-		-
	Yes	-12.6	4.3	0.003
	Gender			
	Male (reference)	-		-
	Female	-4.6	2.06	0.027
	b. Limb fracture before entering full training			
	No (reference)	-		-
	Yes	-12.0	4.5	0.007
	Gender			
	Male (reference)	-		-
	Female	-4.6	2.1	0.03
	c. Fracture **and** MSK before entering full training			
	No (reference)	-		-
	Yes	-11.5	5.7	0.04
	Gender			
	Male (reference)	-		-
	Female	-4.7	2.1	0.03

3.3.5.4 Accounting for sire and dam as random effects

The effect of both dam and sire on model outcomes were examined by including dam and sire as random effects in separate models for all six models in table 17.

When dam was included as the random effect, the influence of injury on the outcome was reduced in every case (Table 17). The coefficient was reduced by between 5% and 22%. However, the standard errors (SE) associated with these coefficients were not significantly altered. All explanatory variables remained significant apart from the model describing the association between fracture **and** MSK and average Official rating, where the p-value including dam as the random effect was now 0.09.

When sire was included as the random effect, the influence of injury on the outcome remained largely unaltered. The coefficients changed by between 0% and 4%. The SE associated with these coefficients were not significantly altered. All explanatory variables in all models remained significant.

Table 17. Accounting for Sire and Dam as random effects

		Dam as random effect				Sire as random effect			
Response variable	Explanatory variable	Coefficient	SE	P-value	*Rho*[9]	Coefficient	SE	P-value	*Rho*[8]
1. Maximum Official Rating	a. Fracture before entering full training								
	No (reference)	-	-	-		-	-	-	
	Yes	-11.2	4.5	0.01		-14.0	4.4	0.002	
	Gender								
	Male (reference)	-	-	-		-	-	-	
	Female	-10.8	2.1	<0.001		-10.2	2.1	<0.001	
					0.29				*0.12*
	b. Limb fracture before entering full training								
	No (reference)	-	-	-		-	-	-	
	Yes	-12.0	4.7	0.01		-14.0	4.6	0.002	
	Gender								
	Male (reference)	-	-	-		-	-	-	
	Female	-10.9	2.1	<0.001		-10.3	2.1	<0.001	
					0.29				*0.10*
	c. Fracture **and** MSK before entering full training								
	No (reference)	-	-	-		-	-	-	
	Yes	-12.2	5.9	0.04		-14.1	5.9	0.02	
	Gender								
	Male (reference)	-	-	-		-	-	-	
	Female	-11.1	2.1	<0.001		-10.4	2.1	<0.001	
					0.30				*0.14*
2. Average Official Rating	a. Fracture before entering full training								
	No (reference)	-	-	-		-	-	-	
	Yes	-10.5	4.2	0.01		-12.7	4.2	0.003	
	Gender								
	Male (reference)	-	-	-		-	-	-	
	Female	-4.9	2.0	0.002		-4.6	2.0	0.02	
					0.20				*0.05*
	b. Limb fracture before entering full training								
	No (reference)	-	-	-		-	-	-	
	Yes	-10.1	4.4	0.02		-12.1	4.4	0.006	
	Gender								
	Male (reference)	-	-	-		-	-	-	
	Female	-5.0	2.0	0.02		-4.6	2.0	0.002	
					0.20				*0.04*
	c. Fracture **and** MSK before entering full training								
	No (reference)	-	-	-		-	-	-	
	Yes	-9.5	5.6	0.09		-12.0	5.6	0.03	
	Gender								
	Male (reference)	-	-	-		-	-	-	
	Female	-5.1	2.0	0.01		-4.7	2.0	0.02	
					0.21				*0.07*

[9] Rho is the proportion of the total variance contributed by the Dam, or the Sire.

4 Discussion

4.1 Summary of findings

The primary aim of this study was to identify juvenile veterinary problems that contribute to a reduced likelihood of training or racing. A second aim was to identify which veterinary problems affect race performance for those individuals that did race at least once. The results suggest that horses that suffer a fracture during their pre-training period are significantly less likely to enter training than the remainder of the cohort, and that those that enter training and subsequently race are likely to have a significantly lower Official rating than those that do not sustain a juvenile fracture. These analyses demonstrate the importance of avoiding serious injury during the first two-years of life for Thoroughbred racehorses.

Musculoskeletal injury or disease, excluding fractures, (MSK) were the most frequently observed veterinary problem within the cohort. Horses with respiratory conditions were the third largest group identified in the study population. MSK was not associated with either the likelihood of getting into training or a reduced level of performance for those horses that did race at least once. Overall, respiratory conditions were also associated with the likelihood of entering training. However, when investigating the effect of specific types of MSK and respiratory problems statistically significant associations were identified for both. For example, recurrent laryngeal neuropathy and suspensory ligament problems were associated with a decreased likelihood of entering training (p-value <0.05).

4.2 Deceased horses

The number of horses that died before entering training (61, 5.8%) in this cohort is comparable to previous studies in which mortality rates have been reported at 8% (Jeffcott *et al.* 1982), 11% (Morley and Townsend 1997) and 4% (Wilsher *et al.* 2006). Notably, Wilsher *et al.* (2006) and Jeffcott *et al.* (1982) surveyed horses into their fourth year, unlike the current study in which a pre training mortality rate is described based on the time period from birth to training age (~2/3 years old). The Morley and Townsend (1997) study focused on deaths up until one year post partum exclusively, reporting an increased mortality rate of 11%, especially considering that the mortality rate prior to horses entering training was just 5.8% in the current study. In the current study, just 2.2% of the study cohort died prior to weaning age, indicating a lower rate of mortality immediately post partum, which is comparable to Morley and Townsend (1997), where 5% of the study cohort died during the first 14 days post partum. Several reasons could account for the differences in mortality rates observed in this study in comparison to previously published work. There may be different management factors and levels of veterinary provision in the current study population. It is possible that dams in the current study are of a younger age than those of previous studies. This fact may account for the observed lower prevalence of foal mortality, as foals born to older dams were significantly more likely to die during the first 14 days of life (Morley and Townsend 1997) and live foal rates have been shown to decrease as dam age increases (Jeffcott *et al*. 1982)

4.3 Veterinary problems

The prevalence of veterinary problems in the current study is high (717/68.8%) when compared to the work by Morley and Townsend (1997), where just 27.1% of horses were identified with a health problem. However, this is most likely to be due to the fact that the authors only followed foals up until the end of their first year post partum, whereas the current cohort was investigated over a longer period of time. This difference probably also reflects the different study designs used in the two studies. In the current study, an extremely comprehensive dataset that included all procedures, such as routine yearling orthopaedic and respiratory screenings, was used. In contrast, Morley and Townsend (1997) relied on owner questionnaire response to provide health problems since birth. A 67% prevalence of developmental orthopaedic disease in Irish Thoroughbred foals has also been reported, demonstrating that the prevalence of veterinary problems can be high (O'Donohue *et al*. 1992) and it is likely that the figure reported by Morley and Townsend (1997) is a significant underestimate of the true situation. Wilsher *et al* (2006) also reported high prevalence of veterinary problems at 62% and 50% in two and three olds in training, respectively.

Unlike the current study, Morley and Townsend (1997) found respiratory infection to be the most prevalent health problem reported by owners, followed by diarrhoea and angular limb deformities. Musculoskeletal problems were most common in the current study but, again, due to the nature of the dataset these problems were more likely to be identified via routine screening. It is also important to remember that the breeding operation under investigation in the current study is one of the larger and most well funded in the industry and, as such, has very intensive veterinary provision which is likely to reduce the likelihood of outbreaks of respiratory infection in the cohort.

Having investigated how pre training veterinary problems affect subsequent performance it would be useful to look at when in this pre training period these problems are most significant. For example, one may hypothesise that fractures or MSK that occur between one year and two years of age are likely to be more significant than those that occur in the first six months.

4.3.1 Likelihood of not entering training

The percentage of horses that successfully entered training under ownership of the stud (61%) was similar to that reported in a study by Jeffcott *et al.* (1982) where 60% of horses entered training. However, it is higher than the figure of 53.5% reported by Wilsher *et al.* (2006). The latter study is potentially more representative of the current wider UK Thoroughbred breeding population given that more than one data source was used and the whole of the foal crop from the Newmarket region for a single year (1999) was included. The difference is potentially due to the fact that the population in the current study are from a large international breeding operation with very intensive veterinary procedures. It is also possible that the bloodlines used by the stud in the current study are genetically less predisposed to injury.

The prevalence of pre training MSK was 31.2% in the study population. More specifically, the prevalence of a range of conditions that might be described as developmental orthopaedic disease (DOD) in the current study population was 17%. In comparison, O'Donohue *et al* (1992) reported that 67% of animals exhibited some form of DOD. However, of those horses that were identified with DOD, just 11.5% required treatment, which is much closer to the figure in the current study. Differences observed are likely to be due to the high level of veterinary early year screening in the current population.

Of those horses that suffered an MSK, 56.7% went into training which was not significantly different to the 61% of the overall cohort that went into training under stud ownership. This indicates that, although MSK's are extremely prevalent, horses affected by these injuries are as likely to enter training as the rest of the cohort i.e. this condition does not adversely affect the likelihood of the animal going into training (p-value= 0.08). Osteochondrosis dissecans (OCD) was the most frequently observed MSK, accounting for 38%, which is higher than the frequency of joint problems observed by Rossdale *et al.* (1985) (14%). However, OCD was not significantly associated with likelihood of entering training when chi squared analysis was applied (p-value= 0.86), and was deemed unlikely to effect the probability of entering training. It is also possible that the higher prevalence of joint problems in the current study compared to the study by Rossdale *et al.* (1985) is due to advanced diagnostic technologies and increased screening since the report was published. The majority of MSK's identified were not associated with likelihood of entering training. In some instances, this may have been due to a lack of statistical power. For example spinal conditions, where none of the three horses identified entered training under ownership of the breeding operation (p-value= 0.06). Nevertheless, those horses that sustained a suspensory ligament problem were significantly less likely to enter training than the rest of the cohort (p-value <0.001). This is perhaps to be expected given that the long term prognosis for Thoroughbred racehorses in training that have sustained a suspensory ligament problem is poor and rarely stabilises (Dyson *et al.* 1995). Such prognoses may influence management decisions on whether to put a horse through training.

The prevalence of fracture observed in the current study (9.9%) is similar to observations in previous studies by Wisher *et al.* (1996) (10 and 9% in two and three year olds respectively). However, the published rates were based on horses in training whereas the current study focused on events prior to training. In the current study, just 37.9% of horses that sustained a juvenile fracture entered training under ownership of the breeding operation. Juvenile fracture may affect an individual's ability to train as time off and restricted exercise for rehabilitation purposes may affect normal development for some horses; thus, delaying or reducing the chance of making it into training. On the other hand, owner perception on the ability of a horse to be a successful racehorse following a fracture may make some more likely to sell on before horses reach this stage.

There was no predominant fracture site observed that resulted in fatality in this study (11/103; 10.7%), unlike Thoroughbreds in flat races, where sesamoid fractures on all weather surfaces, and proximal phalanx fractures on the turf, result in most cases of fatality (Johnson *et al.* 1994; Parkin *et al.* 2004b). Fatal fracture incidence in training is comparable to the current study, (7.4%; 11/148; Verheyen *et al.* 2004) although the lower incidence for horses in training could be attributed to the fact that owners may be more likely to persevere with rehabilitation, rather than resort to euthanasia, for a horse that has proved itself in racing, thus having potential value as a breeding animal.

There were 92 horses with at least one non fatal fracture identified within the study population, of which 42.4% entered training successfully. Proximal sesamoid, distal phalanx, tarsus, and metacarpal/tarsal III fractures were the fracture locations with lowest percentages of horses not entering training. Proximal sesamoid fractures were the most common fracture site in the current study. In other studies (Verheyen and Wood 2004), proximal sesamoid fractures had a low prevalence (10.8%), with the most common fracture sites of horses in training being the third metacarpus (19.6%), the ilium (15.5%), and the tibia (14.2%). These differences are most likely to be due to differences in exercise intensities associated with full training in comparison to horses that have not yet reached this stage.

Given the relatively low prevalence of all fracture types, it is difficult to draw definite conclusions with respect to their influence on a horse's likelihood of entering training. Nevertheless, it does appear that horses that sustained Metacarpal III or proximal sesamoid bone fractures were more likely not to enter training successfully and further investigation to identify risk factors for these specific fracture types is warranted.

In terms of respiratory disease, other than the study by Morley and Townsend (1997), it is difficult to draw meaningful comparisons with previous studies

(Herzog *et al*. 1993b; Olivier *et al*. 1997; Ramzan *et al*. 2008; Rossdale *et al*. 1985) because these studies were conducted in horses in training. Horses in training are more likely to suffer respiratory infection due to greater exposure to pathogens and also the greater likelihood for horses to be identified with upper respiratory tract problems due to increased training/racing pressure on the larynx, which can enhance functional abnormalities that would otherwise be undetected during static endoscopy; i.e. at yearling and pre-sale screenings, as standing endoscopy does not give a clear indication of how the upper respiratory tract will respond under increased pressure/high intensity exercise (Dixon *et al*. 2009; Lane *et al*. 2006). In comparison, the Morley and Townsend (1997) the figure observed in the current study is slightly lower, and this may be due to population differences, levels of veterinary provision, and management techniques.

Although horses identified with a respiratory problem were found to be significantly less likely to enter training than the remainder of the cohort; it is likely that this affect was largely driven by the 37 horses identified with laryngeal problems identified at yearling or pre sale scoping. This is evident when comparing upper and lower respiratory problems; those horses identified with an upper respiratory problem were significantly less likely to enter training than the remainder of the cohort, whereas those identified with a lower respiratory tract problem were not significantly affected. Respiratory screening is performed prior to training so that any functional abnormalities that may affect performance by restricting air flow to the lungs can be detected. Given that recurrent laryngeal neuropathy (accounting for 54% of upper respiratory tract problems in the current study) is regarded as the most important obstructive upper airway disorder of horses (Dixon *et al*. 2009), causing reduced performance (particularly in the racing Thoroughbred) its detection may largely influence whether or not a horse is sent into training.

In every birth cohort, MSK was the most common veterinary problem. However, there was some degree of variation on the prevalence of different problems, for example, the proportion of horses identified with an MSK that were born in 2001 (93.1%) is considerably higher than those horse born in 2000, 2002, 2003 and 2004 (72.9%, 63.4%, 70.7% and 61.2% respectively). Similarly, the proportion of horses identified as sustaining a fracture or respiratory problem that were born in 2000 (50% and 43.8%, respectively) was higher than in all other years. The differences in prevalence of veterinary problems between these years may be due to changes in management, differing vets, or data recording, but without clarification from the stud it is not possible to hypothesise what led to this difference.

The primary outcome measure of success in this study was whether a horse went into training and racing while still under the ownership of the breeding operation that provided the data. We recognise that there may be a bias here that is the result of decisions made by the stud management. However, when investigating the affect of early career veterinary problems on racing performance the race careers of all horses in the original cohort, whether still under the ownership of the breeding operation or not, are included.

4.4 Performance data

There is little previous work that has attempted to identify associations between juvenile veterinary problems and subsequent racing performance. However, when looking at the cohort that had a racing history, some comparisons could be made. The mean number of starts for horses in the present study of 11 is comparable to the mean of 9 starts made by horses in their two and three year old seasons in the study by Wilsher *et al.* (2006). The small difference in figures is most likely to be due to the longer period of time over which race records were collected in the current study i.e. beyond two and three year old seasons.

Larger differences can be seen when comparing the range of starts and earnings. In the current study, the maximum number of starts made by a horse was 90 whereas in the study by Wilsher *et al.* (2006) the maximum number of starts recorded for horses was 14 and 17 in two and three year olds, respectively. The cohort in the current study also had much higher mean total prize money earned (£44146 compared to £2646/£7378 in two and three year olds respectively); median £7282 compared to £0 and £285 in two and three year olds respectively than those in the study by Wilsher *et al.* (2006). However, these figures may have been influenced by one or two top earners, as well as those horses which had a particularly long career, as, in the current study, horses were followed over a period time that gave a maximum career profile for each horse; whereas Wilsher *et al*. (2006) followed just the two and three year old seasons. Another reason for this difference is that the current study was dealing with an elite population of Thoroughbred horses from one high-end breeding operation, whereas Wilsher *et al*. (2006) used data from a mixed population.

It is unclear why fractures were not associated with performance variables other than Official ratings. When considering Official ratings, it is clear that fracture was associated with performance as horses within this group had a low maximum rating of 99 (median of 70; mean = 69), compared to a maximum rating for the rest of the cohort of 145 (median = 82; mean = 81.9). The level of significant association with other measures of performance may be due to nature of racing. Most owners are not in racing for financial gain and horses may be entered into more races from a 'pleasure' perspective, regardless of the quality of the horse. If this is the case, these horses may accumulate more money and starts over a longer period of time, without achieving high Official ratings. The effect of this would be to remove any potential effect of early career fracture on subsequent performance, when measured by starts and earnings. The reason that as big a difference in as many performance variables as might have been expected was not seen may also be due to individuals being removed from the racing population that were, by definition, more fragile than those that were unaffected and were perhaps less likely to perform well anyway. If more of these individuals made it into training (i.e. were allowed to train under ownership of the stud) more significant differences between these groups might have been observed. This also raises the issue of what is an appropriate measure of performance? Race earnings are subject to great variability between prize funds, and in the number of horses that receive money and, although ratings take into account race conditions and past performance, the lack of association between these measures suggests that assessment of multiple variables may be the best way to assess performance accurately (Reardon *et al*. 2008).

There were no significant differences between injured and uninjured horses identified when considering performance variables for MSK's alone, although when looking at those that suffered both an MSK **and** a fracture, affected horses had significantly reduced maximum and average Official ratings. This is perhaps to be expected given that fracture seems to have the most significant effect on performance overall and this result was probably driven by the fact that these horses had sustained fracture at some point. Horses in the MSK category also had a slightly higher mean number of wins (n=1.5) and places (n=2.5) than those that sustained a fracture prior to reaching training age (n=1.3 and 2.3, respectively). However, interestingly, those who sustained a fracture had a slightly higher mean number of starts (n=11.9) than those who suffered an MSK only (n=11.3). On average, horses in both the fracture and MSK groups earned a lower mean amount of prize money during their career (£18229 and £24200 respectively) than the cohort as a whole. They also had performance variables at a lower level throughout, although only maximum and average Official ratings were statistically significantly different.

Horses identified with a respiratory problem prior to training age did not appear to be affected, having a mean number of starts higher than the mean for the entire cohort (n=13.8). Mean lifetime earnings were also higher than that of the whole cohort. However, this was most likely to have been influenced by one top earner with the maximum amount won by a horse in this group being £1,074,965. There were no significant differences in performance variables between those that had suffered a respiratory problem and those that had not. So, despite the fact that trainers have been found to perceive respiratory conditions as the major cause of loss at the training stage (Bailey 1998), such conditions in the early years do not appear to affect future racing performance significantly. However, investigation of more specific respiratory conditions, such as recurrent laryngeal neuropathy (RLN), are likely to identify significant differences with regard to performance in racing. This was not done in the current study due to the lack of statistical power offered by only 36 horses with RLN in the dataset.

4.4.1 Multivariable generalised linear models and accounting for Sire and Dam as random effect

Month of birth, year of birth, and gender were initially added to the data as fixed effects, being the only constant variables available. Gender was the only variable that was retained as being significantly associated with the outcome in all models, with consistent coefficients being produced throughout. However inclusion of gender as a fixed effect had minimal impact on the coefficient for injury type. The models that were produced showed that horses that sustained a fracture prior to entering full training would be expected to earn a maximum Official rating about 14 units lower than unaffected horses and an average Official rating about 12 units lower. It was also shown that female horses would be expected to earn a maximum Official rating about 10 units lower than males and an average rating about 5 units lower. This is perhaps to be expected, given that only 15% of the top 100 horses in UK racing are female, with none in the top ten (www.britishhorseracing.com). It may also be more important for young male horses to demonstrate a very high level of performance (specifically in terms of ratings) as if they are successful they produce a higher financial return as breeding stock.

Heritability has been shown to have an influence on performance (particularly in lifetime earnings) as well as predisposition to illness and injury (Wilsher *et al.* 2006; Wilson and Rambaut 2008). Therefore sire and dam were included in multilevel models based on the original multivariable logistic regression models. Including random effects in models may result in a change in coefficients and/or standard errors. The effect on standard errors is often to increase their size so as to potentially reduce the statistical significance of the variable to which they refer. When including dam or sire as a random effect there was minimal effect on the outcome in any of the models. Dam appeared to have the greatest effect on the association between injury and outcome, reducing in every case and the coefficient changing by up to 22% (4% when including the sire). The greatest effect was observed when considering the official rating with fracture **and** MSK (p-value= 0.09), but this could be due to the relatively low number of horses/data points in this category.

4.5 Future application and further work

There is little published research regarding the management of foals from birth to training age, particularly with regard to maximising likelihood of creating a ‘trainable’ athlete and potential performance. While the stud used in the current study provided detailed information about movement between farms, routine procedures and veterinary intervention, there is little data detailing day to day management. Personal communication with the breeding operation has determined that the majority of fractures, particularly the proximal sesamoid bone fractures, occurred when foals gallop around large, unrestricted paddocks. More detailed information on when, and why, these incidents occur may aid in the design and implementation of management strategies as well as aiding prospective data collection and identification of injury risk factors. It would therefore be appropriate for this stud, and others, to record better what all foals/young horses do during their daily routine and how they are managed. The Hong Kong Jockey Club (HKJC) shows a good example of intense management and data recording, where all racehorses are stabled in one location (Sha Tin racecourse) and all clinical care is provided by a team of veterinarians employed by the HKJC. The HKJC holds an extensive dataset, ensuring that horses demonstrate suitability to race, and uses information collected to identify potential high risk horses (Osbourne *et al*. 2000; Stewart and Watkins 2004) and identify risk factors for injury (Lam *et al*. 2007b). The management techniques demonstrated by the HKJC could provide a good starting point for stud farm management in the UK, where every aspect of strict day to day and weekly management is monitored. Such datasets could be used for retrospective epidemiological studies to identify risk factors for common and significant injuries or veterinary problems. These studies would then form the basis for interventions designed to maximise the productivity of the stud.

Potential management interventions could include: restricting the amount of pasture exercise to reduce the amount of time that foals/young horses are at risk of fracture, or restricting the size of paddocks in order to prevent high speed injury and collisions.

To our knowledge, this particular stud does not have exercise regimens in place for its foals or young horses. In order to try and reduce the occurrence of serious injury such as fracture, some form of training schedule could also be considered. As more recent studies have focused on musculoskeletal adaptation through exercise, and given that these problems seem to have the biggest impact in this study, it may be worthwhile investigating the possibilities of a management programme within the breeding operation that aims to reduce the incidence of injury. Several research groups are investigating the potential to increase bone and soft tissue/joint strength prior to entering training. However, although such programmes have not been shown to have any detrimental effects, the benefits have as yet proven minimal when compared to the exercise benefits of free pasture exercise (Brama *et al.* 2002; Brama *et al.* 2009; Kim *et al.* 2009; Moffat *et al.* 2008; Rogers *et al.* 2008a, 2008b; van de Lest *et al.* 2002, 2003).

Although this dataset was relatively large in that it included more than 1000 foals, the fact that it was from just one stud suggests that it may not be representative of the whole Thoroughbred population. The use of a larger dataset, involving multiple stud farms, to allow further development of the methods and refinement of the dictionary categories would be beneficial when considering the impact on the racing/equine industry as a whole. Use of a larger dataset would also increase the power of statistical analyses and would allow the investigation of the association between other common veterinary problems and performance that were not the focus of the current study.

The likely success of recruiting more studs into such a study has not been investigated. Such a study would present problems concerning confidentiality, anonymity, trust between studs, and the sharing of data. Nevertheless a retrospective study would improve the representativeness of the UK Thoroughbred breeding population as well as increasing statistical power and should therefore be considered.

Another alternative would be a prospective case-control study, ideal for rare outcomes (Dohoo *et al.* 2003). This would involve enrolling a number of studs with similar management and data recording tools that each have a representative that informs the study team of the occurrence of a ‘case’, which would then be followed up by the selection of a number of unaffected controls from the same stud population. A limitation of this approach, however, would be that recruiting multiple studs, incorporating many vets, has the potential to reduce the consistency of cases definitions. Potential risk factors could be investigated such as management, exercise regimes, dam age and parity (Verheyen *et al.* 2007), or birth dates, depending on the case definitions under investigation. A further option would be to provide studs with a computerised dataset with which to record information that would be required for the study, a method which has been previously used successfully by Verheyen and Wood (2004b).

As an indication of the sample size required to investigate risk factors for limb fracture, for example, one would need to recruit approximately 200 cases and 600 controls (based on a 1:3 case:control ratio) to identify odds ratios of at least 2+ (with 82% power and 95% confidence) given a range of prevalence of exposure in the control population between ten and 85 percent.

For these data and for other cohorts it would also be interesting to investigate the use of survival analysis which would enable the identification of risk factors for several of the common types of veterinary problem in the same study.

4.6 Limitations

The challenges in this study primarily revolved around the way in which the dataset was managed, both at the stud and veterinary level. For example, at the stud over the period of the investigation there were changes to the way records were updated and, in certain instances, veterinary reports were vague and sometimes incomprehensible (see Appendix 3). A further issue was the fact that multiple veterinarians compiled reports that were included in the dataset. This resulted in inconsistencies between reports, with differing veterinarians using different terminology or differing levels of detail in reports. There is also the chance that they had different sensitivities and specificities for disease presentation.

Management of the whole dataset seemed to differ over time, possibly due to changes in management, resulting in variations in the way in which data were entered into the system. Data were also frequently entered incorrectly into the system (in different fields) resulting in time-consuming investigation on the part of the research scientist in order to ascertain the correct information. Such problems included: missing veterinary reports, incorrect procedure date entry, and delays in uploading of veterinary reports, resulting in reports from a particular veterinary episode being in incorrect chronological order and a lack of information, as not all reports were attached. The stud has since recognised some of these deficiencies and has designed a new equine management database that should, in future, improve the quality of the data.

There were a number of horses (122) in the study cohort that did not enter training under the stud's ownership but were then found to have a performance record. All of these horses were sold immediately prior to the time that they would have been expected to enter training and therefore would have had very little opportunity to sustain an injury before entering training while under the new ownership. Therefore, any of these horses that sustained a veterinary problem were included in the group of horses that were free from injury. It is possible that a small number of these horses sustained an injury very soon after being sold and were therefore misclassified. It was also not possible to collect the whole career for all horses in the cohort (i.e. if horses continued to race past May 2009); however, it is likely that the vast majority of their career, the two, three and four year old flat racing seasons, would have been included.

A particular limitation in this dataset occurred when horses left the management of the breeding operation when entering training, being sold or 'shared' as part of a scheme with partnering studs. The dataset provides no indication as to why these decisions were made. Bearing this in mind, it would be highly beneficial if a reason for sale, or perhaps a summary report of the 'career' of each horse, was included within the management system when horses left stud management. This could also be adapted for those horses that died so that a diagnosis could be identified easily without having to read through lengthy pathology reports.

Due to the difficulties encountered within the dataset, time constraints meant that only three veterinary problem groups could be investigated in detail. Clearly, there is scope for further refinement of case definitions and investigation of associations between these and performance. For example, the large MSK group could be further sub divided. These investigations will be the focus of future smaller projects with the stud.

The fact that we used the rest of the cohort including those with other injuries as controls may have resulted in an underestimate of the size of effect of veterinary problems on the outcomes under investigation. This would be the case if there were common risk factors for two different types of injury (one of which formed part of the 'affected' group and one of which formed part of the control group).

4.7 Was content analysis useful?

Seventy one percent of horses were identified with a veterinary problem in the dataset, although a large amount of the work was done manually. Content analysis was useful as it helped to identify particular problems within this dataset but its application to a cleaner, more well-defined dataset would be more rewarding.

Lengthy vet reports were difficult to interpret and conclude quickly. Again, following the HKJC's lead, a second field within the data management software including a sentence at the end of each injury or disease episode summarising the event (including diagnosis, treatment, and conclusion/prognosis) would be highly useful. When used on HKJC data this proved advantageous as it allowed more rapid, accurate content analysis with little manual input (Lam *et al.* 2007b). Lam *et al.* (2007b) reported that only three weeks were required to categorise 95% of 4000+ reasons for retirement in Hong Kong successfully. This was largely due to the much more refined nature of the reports used in that study.

5 Conclusions

To the best of our knowledge this study has been the first to analyse stud-level data with content analysis. This study has shown that content analysis is a useful tool when dealing with retrospective data. The nature of this particular dataset restricted its use to potential case identification as there were a number of false positives that required further manual investigation. As mentioned previously (chapter 4), several modifications to the dataset have been suggested that would increase the efficiency of the methods used in this study.

One of the key issues that came to light during this study is the definition of ‘success’. Success was measured in two ways in this investigation. The first, identifying which horses enter training under ownership of the stud, is perhaps not representative of ‘success’ for the wider Thoroughbred population. The reliability of this as a measure of success is open to question as the decision that is made whether or not to put a horse through training is partially a subjective decision made by stud management, and it is not known whether the problems that we have identified have contributed towards this decision making. However, at individual stud-level this information could be very useful; particularly retrospectively, where management may analyse whether correct decisions were made in conjunction with the second measure of ‘success’, performance in racing.

Performance data appear to be more representative in terms of ‘success’ as they allows us to see how early medical history could affect a horses’ career on the racecourse. A successful career in racing would ultimately benefit the stud, with successful progeny leading to increased stallion fees and more valuable broodmares. It is, however, still unclear which measure of performance should be used to judge a successful outcome.

In the current study, although several measures of performance were explored, Official rating was the only consistently significant outcome, whereas in other studies financial returns through prize money and number of starts (Jeffcott *et al*. 1982; More 1999; Wilsher *et al*. 2006) have been the chosen measure of performance representing ‘success’. To date, a consensus on what is the most appropriate measure of performance has not been reached. This should be one of the foci of future work in this field of research.

This study has emphasised the importance of avoiding serious injury, such as fracture, during the first two years of life for Thoroughbred racehorses. However, further work is required to focus more closely on specific injury/health problems in relation to future performance, which will in turn assist studs and veterinarians in making informed decisions regarding the management of young horses.

Although this study has identified the major priorities (in terms of veterinary problem groups) contributing to loss in the Thoroughbred breeding industry, additional work is necessary to identify and initiate potential management techniques that may aid in minimising the risk of injury in the early years of a Thoroughbred's career. The use of a larger dataset, involving multiple stud farms, would allow further development of the methods and refinement of the dictionary categories and increase the validity of the study when considering the impact of potential risk factors on the racing/equine industry as a whole.

Appendix 1. Dictionary for content analysis

List of dictionary categories and associated words for each veterinary problem group

Dermatological
• dermatophilis
• dermatophilus
• ear_tooth
• lice
• mud_fever
• oncoceriasis
• rain_scald
• ring_worm
• sarcoid
• skin_allergy
• wart

Fore Limb Lameness
• break_down_lf
• break_down_re
• chronic_lameness_left_fore
• chronic_lameness_right_fore
• lame_left_fore
• lame_on_the_left_fore
• lame_on_the_right_fore
• lame_right_fore
• shoulder_injury
• shoulder_lameness

Fracture
• comminute
• fracture
• fractures
• frcture
• frontal
• slab
• spiral

Gastrointestinal
• colic
• colic_surgery
• cranial_displacement_of_the pelvic_ flexure
• gastric_impaction
• gastric_ulcer
• gastric_ulceration
• hernia
• impaction
• intestinal_abnormality
• intussuception
• laparotomy
• lipoma
• nephresplenic_entrapment
• oesophageal
• oesophageal_cyst
• parasite
• parasites
• stomach
• ulceration

Hind Limb Lameness
• chronic_lameness_left_hind
• chronic_lameness_right_hind
• hindlimb_lameness
• lame_behind
• lame_both_hind
• lame_in_the_left_hind_limb
• lame_in_the_left_hindlimb
• lame_in_the_right_hind_limb
• lame_in_the_right_hindlimb
• lameness_both_hind
• lameness_left_hind
• lameness_right_hind
• left_stifle_lameness
• remodelling_of_the_central_tarsal bone
• right_stife_lameness

Musculoskeletal
- angular_limb_deformity
- arthritic
- arthritis
- arthrocentesis
- arthroscopy
- bone_cyst
- bursitis
- capsular_new_bone
- carpitis
- chronic_djd
- contracted_deformity
- contracted_foot
- contracted_hoof
- correctively_farriery_in_the_right forelimb
- currently_is_lame
- ddft
- deep_digital_flexor_tendon
- degenerative_changes
- degenerative_joint_disease
- deposit_of_new_bone
- desmitis
- digital_hyper_extension
- dislocation
- distal_screw
- distended
- distended_and_sore_right_fetlock_joint
- distended_left_joint
- djd
- enlarged_fetlock_joint
- enlargement_of_the_distal_metacarpal
- epiphysitis
- flexural_deformity

Infection
- abcess
- abscess
- abscesses
- absesses
- cellulitis
- chronic_infection
- equine_herpes_virus
- equine_infectious_anaemia
- equine_influenza
- equine_viral_arteritis
- infection
- mucopurulent_discharge
- pyrexia
- pyrexic
- r_equi
- r-equi
- rhodococcus_equi
- rhodococus_equi
- tapeworm_infection
- worrying_blood_result
- joint_infection
- navicular
- ocd
- osteoarthritis
- osteochnodrosis
- osteochondrotic
- osteoma
- periodically_lame
- periosteal_strip
- pulled_ligaments_in_stifle
- pus_in_the_foot
- sdf
- sdft
- septic_joint
- sesamoidean
- splint
- suspensor
- suspensory
- tendinitis
- tendonitis
- tenosynovitis
- toes_out_both_front_limbs
- valgus
- varus

Neurological
- ataxia
- ataxic
- compression_of_the_spinal_cord
- neurological_exam
- wobbler

opthalmic
- cataract
- corneal_ulcers
- cornela_ulcer
- entropin
- epithelial_iris_cyst
- eyelid_laceration
- eyelid_trauma
- opthalmologicalabnormality

Reproductive - Female
- abortion
- acute_endometritis
- chronic_endometritis
- mastitis
- ovarian_cyst
- post_partum_colic
- prolapse_of_uterus
- prolapse_of_vagina
- twinned
- twinning
- twins
- uterine_cyst
- uterine_prolapse
- vaginal_discharge
- vulval_aspiration

Reproductive - Foal
- angular_limb_deformity
- ankylosis
- failure_of_transfer_of_colostral immunity
- haemolytic_disease
- haemolytic_foal_disease
- off_the_suck
- orphan
- retained_meconium
- severe_combined immunodeficiency

Reproductive - Male
- abnormal_situation_of_both testicles
- bilateral_castration
- cryptochidism
- inguinal_hernia
- injury_to_penis
- orchitis
- paraphimosis
- rig
- right_testicle_to_be_in_the ingunal_ring
- shorter_testis_cords
- squeezed_by_the_right_hindlimb
- testicular_tumor
- testis_in_the_i ngu i nal_canal
- veneral_disease

Respiratory
- airway_obstruction
- cough
- coughing
- ddsp
- dorsal_dosplacement_of_the_soft palate
- eiph
- epiglottal_entrapment
- epiglottic_entrapment
- epistaxis
- guttoral_pouch
- inspriatory
- nasal_discharge
- pharyngitis
- pleuropneumonia
- pneumonic_chnages
- recurrent_laryngeal_neuropathy
- respiratory_noise
- respiratory_noise
- roarer
- roaring
- sinus
- sinusitis
- sub_epiglottic_cyst
- upper_respiratory_tract_infection

Appendix 2. Performance variable testing

Histograms of performance variables - testing for normal distribution. Descriptive statistics and testing for equal variance.

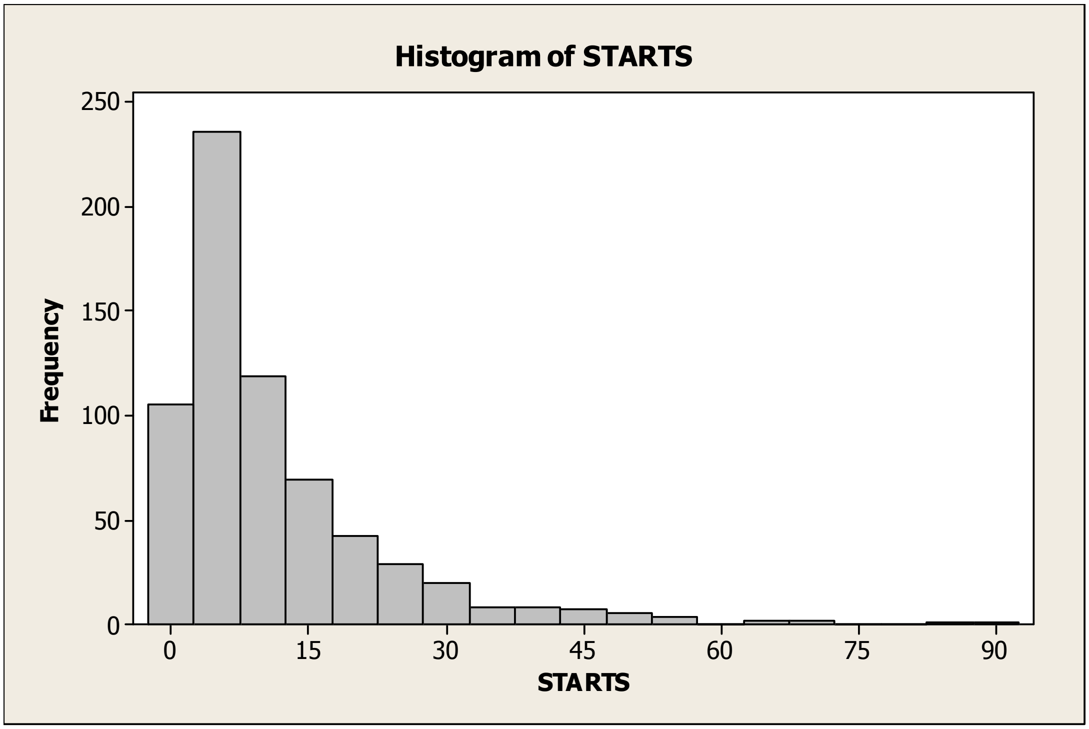

Figure 2 - No. of starts

Not normally distributed – skewed left

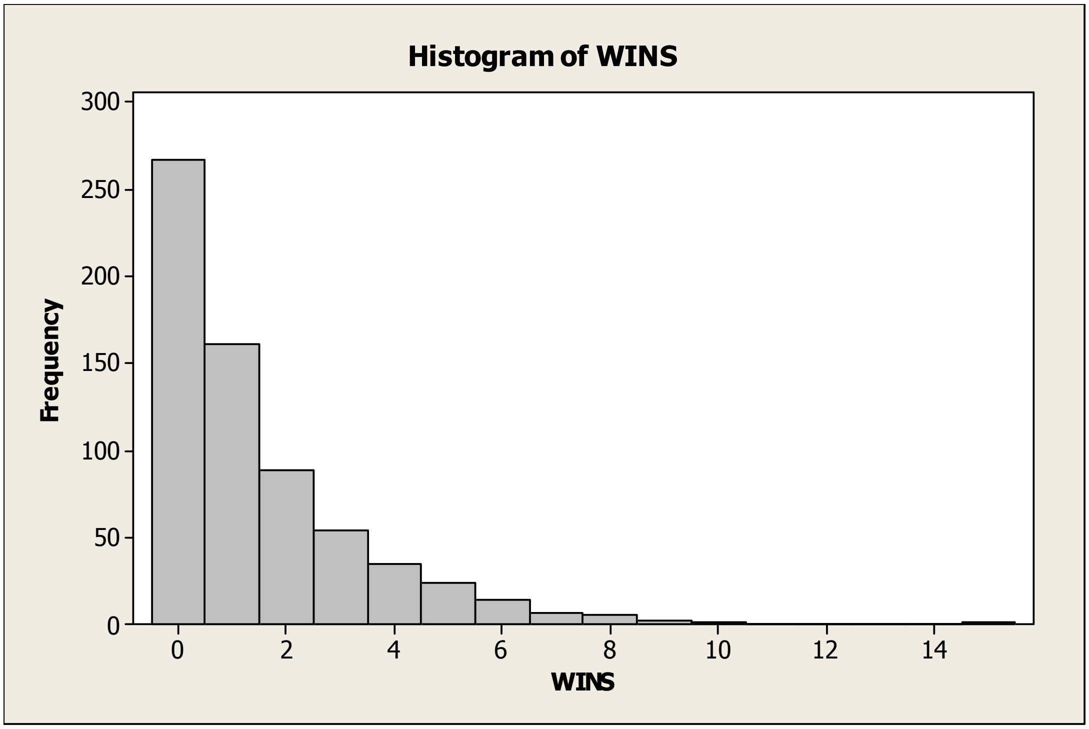

Figure 3 - No. of wins
Not normally distributed – skewed left

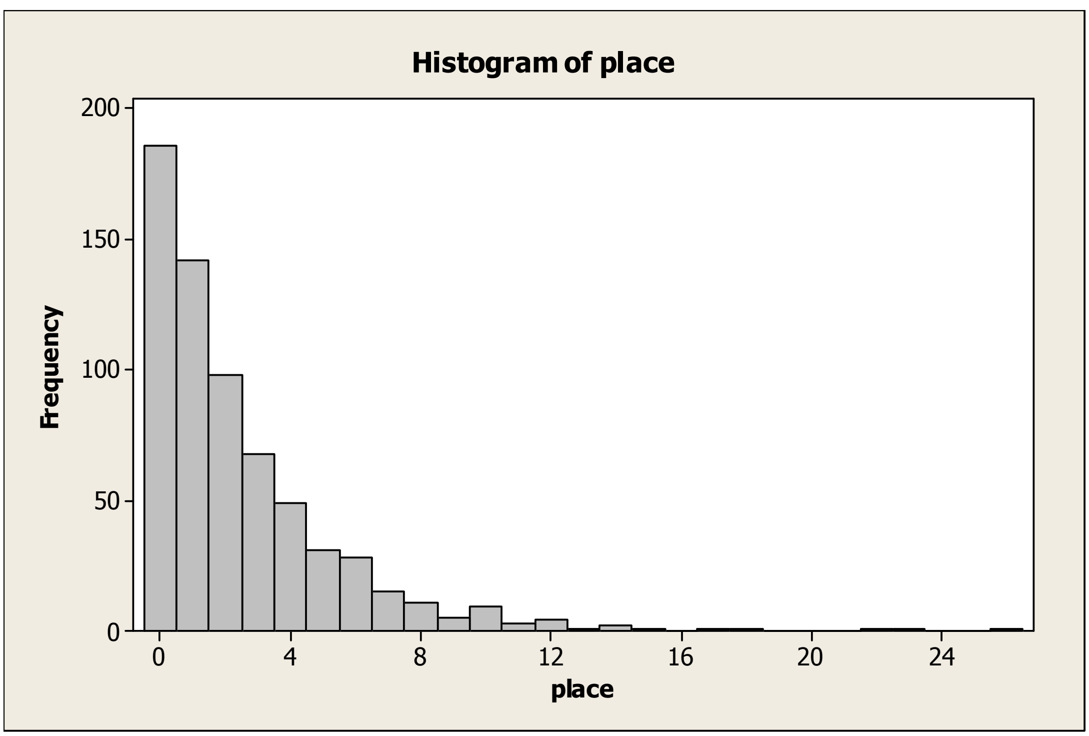

Figure 4 - No. of places
Not normally distributed – skewed left

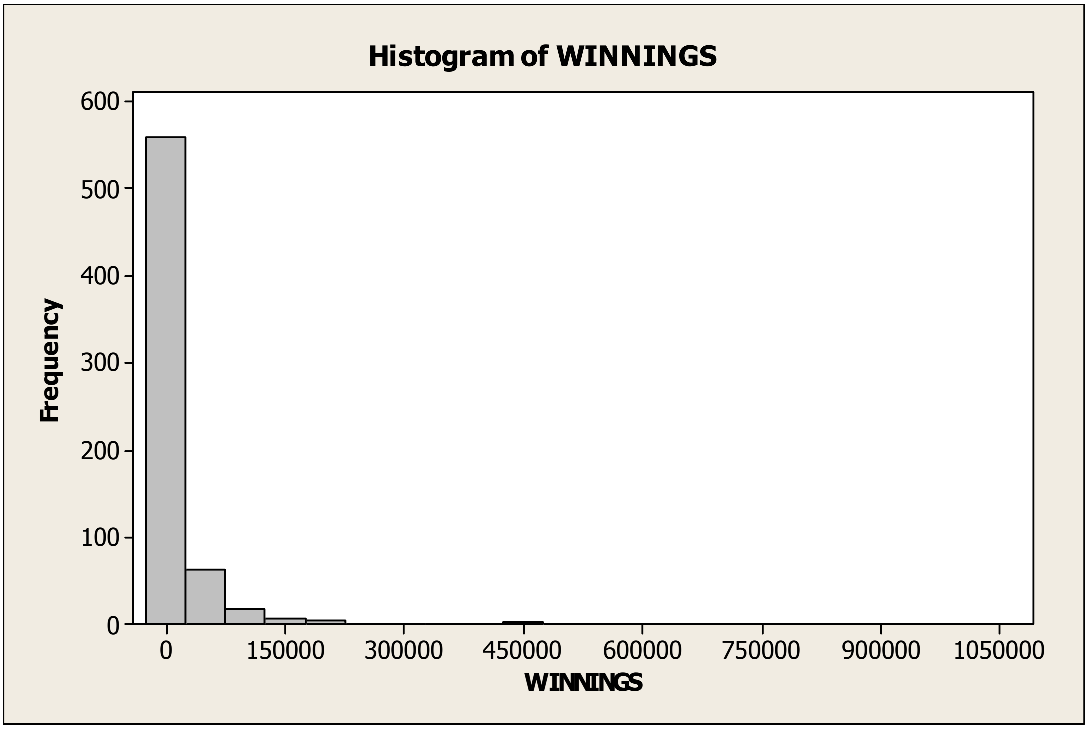

Figure 5 – Winnings
Not normally distributed – skewed left

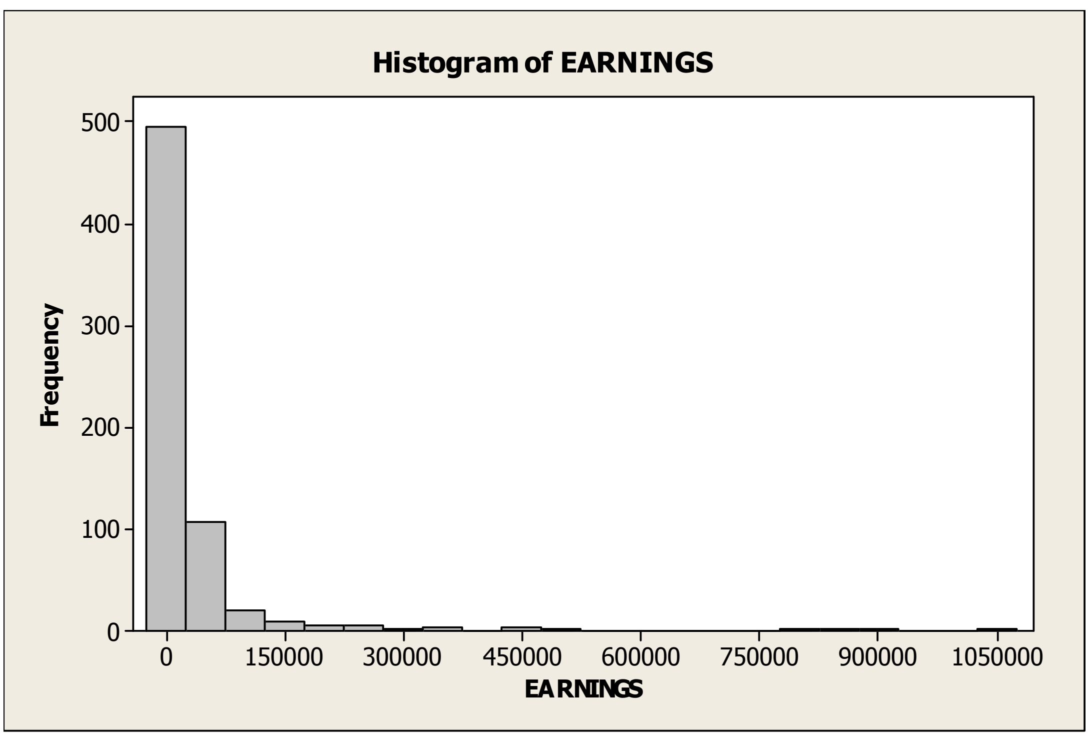

Figure 6 – Earnings
Not normally distributed – skewed left

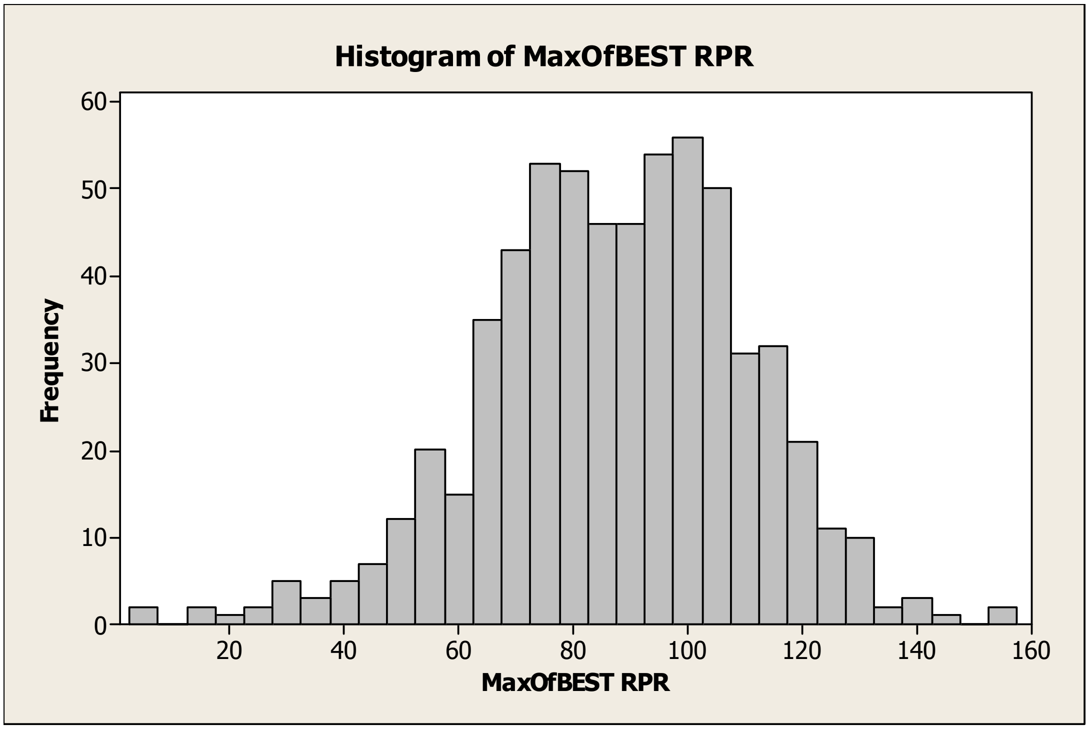

Figure 7 - Maximum RPR
Normally distributed?

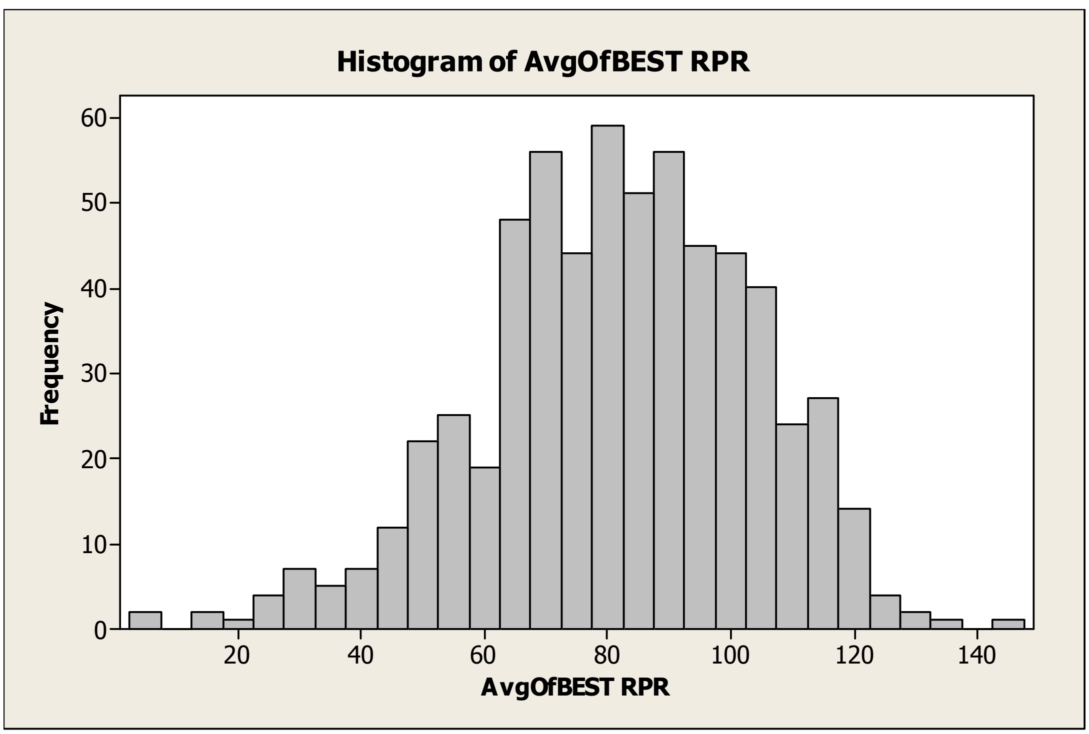

Figure 8 - Average RPR
Normally distributed? Slight right skew?

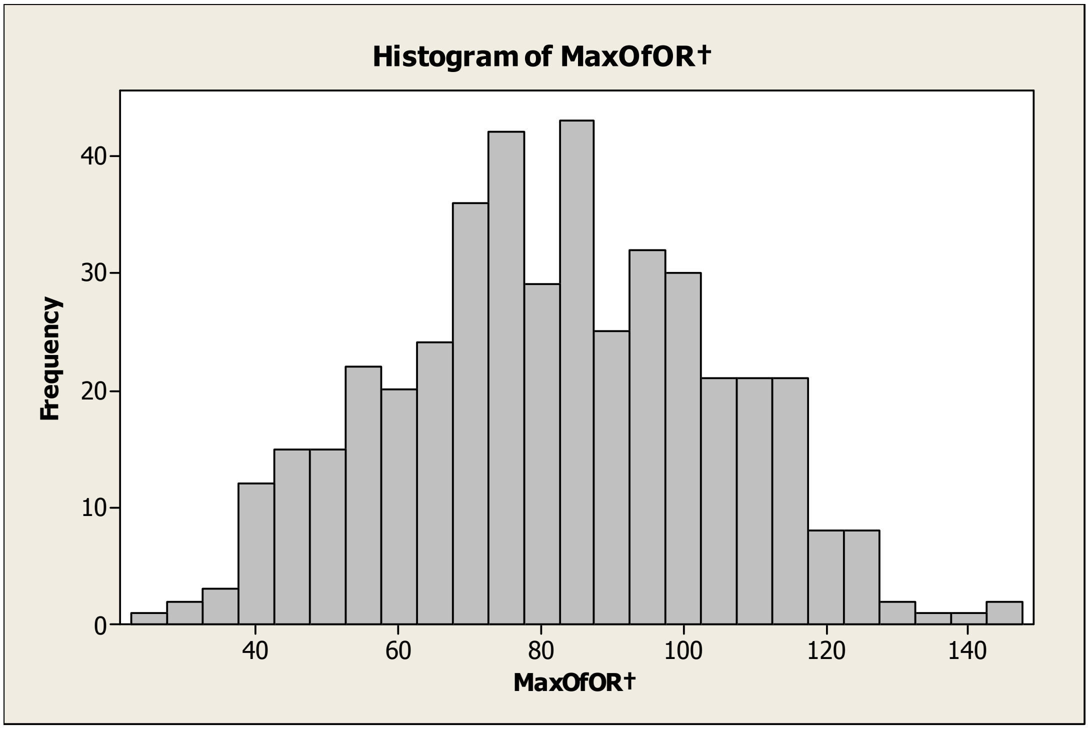

Figure 9 - Maximum OR
Normal distribution?

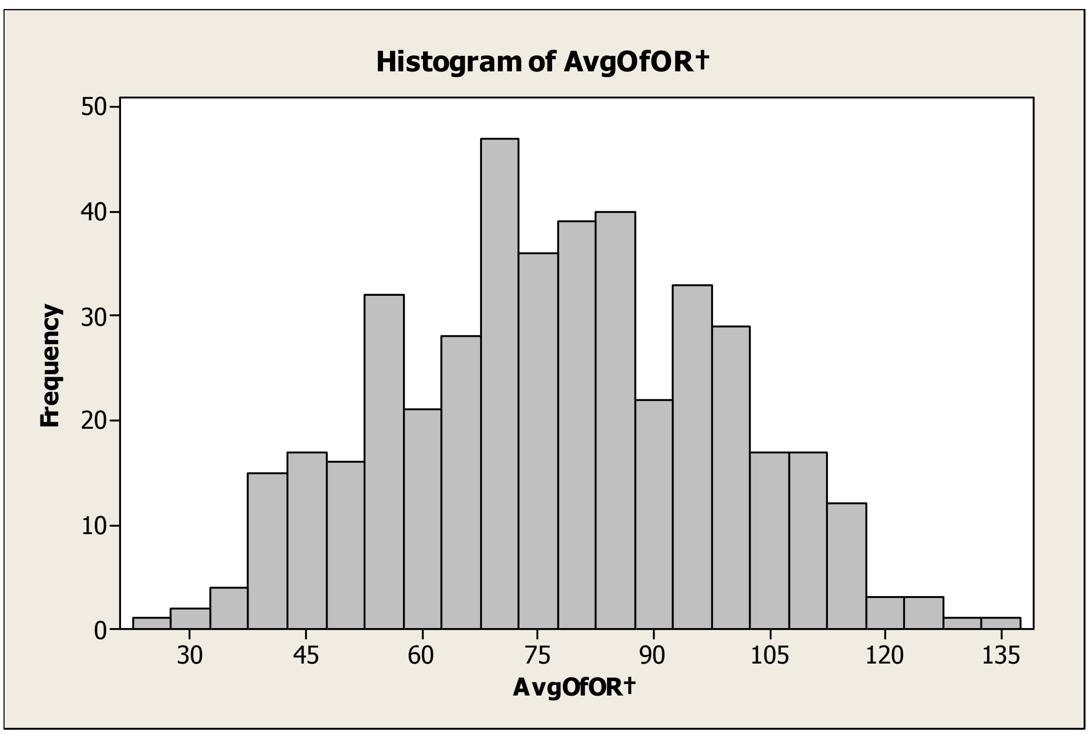

Figure 10 - Average OR
Normally distributed?

Table 18. Performance variables – descriptive statistics

	n	mean	median	Min	max	StDev	IQ1	IQ3
Starts	658	11.290	7	1	90	12.045	4	15
Wins	658	1.482	1	0	15	1.898	0	2
Places	658	2.48	2	0	26	3.130	0	3.250
Winnings	658	19040	4071	0	1070413	64424	0	13439
Earnings	658	32046	7282	0	1074965	94080	1155	24828
Mean RPR	622	81.552	82	4	142.5	22.251	67.875	97.750
Max RPR	622	87.331	88	4	157	22.860	73	103
Mean OR	436	77.33	77	27	137	20.99	62.5	94
Max OR	436	81.91	82	27	145	22.76	66	98

Table 19. Testing for Normality

	n	Mean	Median	Min	Max	StDev	IQ1	IQ3	P value
Start non frac	606	11.243	7	1	85	11.518	4	15	<0.010
Start frac	52	11.85	5.5	1	90	17.18	2	13	<0.010
Win non frac	606	1.495	1	0	10	1.840	0	2	<0.010
Win frac	52	1.327	1	0	15	2.495	0	1	<0.010
Place non frac	606	2.498	2	0	26	3.144	0	3.250	<0.010
Place frac	52	2.269	1	0	13	2.978	0	3.750	<0.010
Winnings non frac	606	19748	4222	0	1070413	66761	0	14032	<0.010
Winnings frac	52	10792	2188	0	115047	22796	0	8537	<0.010
Earnings non frac	606	33232	7369	0	1074965	97382	1221	26076	<0.010
Earnings frac	52	18229	6568	0	183782	36240	263	14995	<0.010
MaxRPR non frac	573	87.759	89	4	157	22.889	73	103	0.046
MaxRPR frac	49	82.33	83	31	121	22.14	69	99.5	>0.150
MeanRPR non frac	573	81.780	82.5	4	142.5	22.307	68	98.625	0.049
MeanRPR frac	49	78.89	81	31	121	21.64	66	92.63	>0.150
MaxOR non frac	411	82.72	83	27	145	22.78	67	100	>0.150
MaxOR frac	25	68.96	70	30	99	18.37	55.5	82.5	>0.150
MeanOR non frac	411	78.04	78.67	277	137	21.03	63.5	94	0.055
MeanOR frac	25	65.69	67.5	30	99	16.74	55	78.75	>0.150
Start non limb frac	610	11.239	7	1	85	11.546	4	15	<0.010
Start limb frac	48	11.94	6	1	90	17.33	2.25	13	<0.010
Win non limb frac	610	1.4918	1	0	10	1.8379	0	2	<0.010
Win limb frac	48	1.354	1	0	15	2.572	0	1	<0.010
Place non limb frac	610	2.489	2	0	26	3.139	0	3.250	<0.010

Place limb frac	48	2.375	1	0	13	3.036	0	3.750	<0.010
Winnings non limb frac	610	19638	4165	0	1070413	66556	0	13966	<0.010
Winnings limb frac	48	11441	2851	0	115047	23598	0	8537	<0.010
Earnings non limb frac	610	33043	7331	0	1074965	97091	1199	26048	<0.010
Earnings limb frac	48	19376	6602	0	183782	37469	428	14995	<0.010
MaxRPR non limb frac	576	87.655	89	4	157	22.911	73	103	0.040
MaxRPR limb frac	46	83.28	84.5	31	121	22.06	69.75	100.25	>0.150
MeanRPR non limb frac	576	81.677	82	4	142.5	22.315	68	98.188	0.056
Mean RPR limb frac	46	79.98	82	31	121	21.62	66.5	94.25	>0.150
MaxOR non limb frac	413	82.65	83	27	145	22.76	66.5	99.5	>0.150
MaxOR limb frac	23	68.96	70	30	99	18.78	55	83	>0.150
MeanOR non limb frac	143	77.95	78	27	137	21.02	63.08	94	0.053
Mean OR limb frac	23	66.22	67.67	30	99	17.33	55	81.5	>0.150
Start non MSK	453	11.318	7	1	72	11.806	4	14.5	<0.010
Start MSK	205	11.229	7	1	90	12.587	3.5	15	<0.010
Win non MSK	453	1.4724	1	0	10	1.8132	0	2	<0.010
Win MSK	205	1.502	1	0	15	2.074	0	2	<0.010
Place non MSK	453	2.450	2	0	26	3.075	0	3.5	<0.010
Place MSK	205	2.546	1	0	23	3.255	0	3.5	<0.010
Winnings non MSK	453	20576	4127	0	1070413	70624	0	13971	<0.010
Winnings MSK	205	15647	3969	0	473166	47946	0	11883	<0.010
Earnings non MSK	453	35597	7878	0	1074965	105455	1167	26204	<0.010
Earnings MSK	205	24200	6712	0	495159	61446	1104	19460	<0.010
MaxRPR non MSK	430	88.7	90	14	157	22.06	74.75	103	>0.150
MaxRPR MSK	192	84.26	86	4	140	24.34	69	102	0.088
MeanRPR non MSK	426	81.29	83	4	128	22.5	66.25	99.13	0.040

MeanRPR MSK	196	82.12	81.5	7	142.5	21.74	70	95	>0.150
MaxOR non MSK	294	81.59	83	27	145	23.02	65	98.25	>0.150
MaxOR MSK	142	82.65	80	40	144	22.28	67.5	98.5	0.078
MeanOR non MSK	294	76.79	77	27	125	21.27	59	94	0.043
MeanOR MSK	142	78.43	78	38.5	137	20.44	64.38	137	>0.150
Start non resp	603	11.060	7	1	90	11.758	4	14	<0.010
Start resp	55	13.82	8	1	55	14.73	4	17	<0.010
Win non resp	603	1.4561	1	0	15	1.8577	0	2	<0.010
Win resp	55	1.764	1	0	9	2.301	0	3	<0.010
Place non resp	603	2.401	1	0	26	2.998	0	3	<0.010
Place resp	55	3.345	2	0	22	4.261	0	5	<0.010
Winnings non resp	603	17876	4056	0	603583	51243	0	13433	<0.010
Winnings resp	55	31801	4368	0	1070413	145058	0	13923	<0.010
Earnings non resp	603	31116	7112	0	879684	87523	1184	22750	<0.010
Earnings resp	55	42238	8071	0	1074965	148911	942	29731	<0.010
MaxRPR non resp	570	887.372	88	4	157	22.549	73	103	0.075
MaxRPR resp	52	86.88	89.50	14	133	26.27	69.75	105.75	>0.150
MeanRPR non resp	568	81.653	82.250	4	134.5	21.973	68	97.625	0.071
MeanRPR resp	54	80.49	79.83	26.5	142.5	25.2	65.25	99.44	>0.150
MaxOR non resp	398	81.56	82	27	145	22.51	66.75	98	>0.150
MaxOR resp	38	85.79	89.50	45	144	25.21	63.75	105.25	>0.150
MeanOR non resp	398	77.02	77.25	27	130	20.62	63.29	91.17	0.099
MeanOR resp	38	80.51	76.04	45	137	24.67	57.5	100.25	>0.150
Start non frac/MSK	626	11.150	7	1	85	11.448	4	15	<0.010
Start frac/MSK	32	14.03	6	1	90	20.61	2.25	16.25	<0.010
Win non frac/MSK	626	1.4776	1	0	10	1.8340	0	2	<0.010

Win frac/MSK	32	1.563	1	0	15	2.929	0	2	<0.010
Place non frac/MSK	626	2.468	2	0	26	3.122	0	3	<0.010
Place frac/MSK	32	2.719	1	0	13	3.333	0	4	<0.010
Winnings non frac/MSK	626	19474	4071	0	1070413	65893	0	13772	<0.010
Winnings frac/MSK	32	10553	3913	0	62767	18629	0	9707	<0.010
Earnings non frac/MSK	626	32800	7183	0	1074965	96208	1155	25974	<0.010
Earnings frac/MSK	32	17290	9697	0	98724	27155	1051	16861	<0.010
MaxRPR non frac/MSK	590	87.610	88	4	157	22.767	73	103	0.048
maxRPR frac/MSK	32	82.19	85	7	121	24.32	69.25	99.75	>0.150
MeanRPR non frac/MSK	591	81.573	82	4	142.5	22.399	67.5	98	0.049
MeanRPR frac/MSK	31	81.15	82	36	121	19.54	69	94	>0.150
MaxOR non frac/MSK	422	82.33	83	27	145	22.87	66	99	>0.150
MaxOR frac/MSK	14	70	70	40	94	15.19	65.25	78.25	>0.150
MeanOR non frac/MSK	422	77.67	78	27	137	21.11	62.21	94	0.052
Mean OR frac/MSK	14	66.90	67.58	40	88	13.73	61.75	77.38	>0.150

Table 20. Test for equal variance

	Test	P value
Start fracture	Levene’s	0.250
Win fracture	Levene’s	0.837
Place fracture	Levene’s	0.973
Winnings fracture	Levene’s	0.355
Earnings fracture	Levene’s	0.285
MaxRPR fracture	F	0.803
MeanRPR fracture	F	0.823
MaxOR fracture	F	0.204
MeanOR fracture	F	0.179
Starts limb fracture	Levene’s	0.312
Wins limb fracture	Levene’s	0.924
Places limb fracture	Levene’s	0.877
Winnings limb fracture	Levene’s	0.415
Earnings limb fracture	Levene’s	0.338
Max RPR limb fracture	Levene’s	0.717
MeanRPR limb fracture	F	0.823
MaxOR limb fracture	F	0.281
MeanOR limb fracture	F	0.278
Starts MSK	Levene’s	0.856
Wins MSK	Levene’s	0.798
Places MSK	Levene’s	0.664
Winnings MSK	Levene’s	0.352
Earnings MSK	Levene’s	0.153

MaxRPR MSK	F	0.82
Mean RPR MSK	Levene's	0.172
Max OR MSK	F	0.668
Mean OR MSK	Levene's	0.402
Starts resp	Levene's	0.075
Wins resp	Levene's	0.103
Places resp	Levene's	0.031
Winnings resp	Levene's	0.117
Earnings resp	Levene's	0.389
MaxRPR resp	F	0.110
MeanRPR resp	F	0.145
MaxOR resp	F	0.304
MeanOR resp	F	0.106
Starts frac/MSK	Levene's	0.036
Wins frac/MSK	Levene's	0.739
Places frac/MSK	Levene's	0.467
Winnings frac/MSK	Levene's	0.439
Earnings frac/MSK	Levene's	0.351
MaxRPR frac/MSK	Levene's	0.937
MeanRPR frac/MSK	F	0.3636
MaxOR frac/MSK	F	0.091
MeanOR frac/MSK	F	0.077

Appendix 3. Example of veterinary report

An example of two veterinary reports within the dataset

Results

P-O Reaction RH Fetlock, RH Fetlock (0.5) - slight reaction proximal physis proximal P1 Spur R Hock (0.5) - small spur distal central tarsal bone., R Hock (0.5) - small spur distal central tarsal bone. P-O Reaction L Knee (0.5) - mild epiphysitis, R Knee (0.5) - mild epiphysitis. OCD Lesion R Stifle (1), Review - 10 x 2 mm subchondral lesion, lat.trochl.ridge.; no effusion., R Stifle (1), Review - 10 x 2 mm subchondral lucency, lateral trochlear ridge Category:- III

Results

P-O Reaction LH Fetlock (1) - Plantaroproximal P1, RH Fetlock (1) - Plantaroproximal P1, L Knee (1) - Mild physitis distal radius; right > L; monitor clinically, R Knee (1) - Mild physitis distal radius; right > L; monitor clinically OCD Lesion R Stifle (1.5), Review - Small lesion lateral trochlear ridge of femur. Recommend further x-ray's; also assess clinically for lameness and / or joint distention. Category:- III

Appendix 4. Racing performance descriptive statistics according to specific veterinary problems.

These results require further refinement as multiple combinations of veterinary problems were seen in individual horses and the tables in this appendix are purely to demonstrate to the scope of the data. The data in these tables refer to the 2000-2004 cohort described from chapter 3.2 onwards.

4.1 Musculoskeletal injury or disease (excluding fractures) (MSK) (n = 326)

type	Mean starts	Minimum starts	Maximum starts	n
ARTHRITIS	5.6	3.0	11.0	5.0
CHECK LIGAMENT DESMOTOMY	27.0	27.0	27.0	1.0
BONE CYST	9.0	3.0	21.0	4.0
BONE CYST, LYSIS	35.0	35.0	35.0	1.0
EPIPHYSITIS	7.0	3.0	11.0	2.0
JOINT DISTENSION	3.5	3.0	4.0	2.0
JOINT FLUSH	16.5	14.0	19.0	2.0
LIGAMENT PROBLEM	5.0	5.0	5.0	1.0
NUMEROUS MSK	5.0	1.0	8.0	5.0
OCD	10.6	1.0	70.0	66.0
OCD, BURSITIS	25.0	25.0	25.0	1.0
OCD, JOINT FLUSH	25.0	25.0	25.0	1.0
OCD, LIGAMENT PROBLEM	12.0	12.0	12.0	1.0
OCD, LOCKING STIFLE	31.0	31.0	31.0	1.0
OCD, PERIOSTEAL ELEVATION	5.0	5.0	5.0	1.0
OCD, TRANSPHYSEAL SCREW	10.5	9.0	12.0	2.0
LAMINITIS, OCD, SESAMOIDITIS	11.0	11.0	11.0	1.0
OCD, SESAMOIDITIS	10.3	2.0	23.0	4.0
OCD, SESAMOIDITIS, PHYSITIS, PERIOSTEAL REACTION	7.0	7.0	7.0	1.0
PEDAL BONE ABNORMALITY	4.0	4.0	4.0	1.0
PINFIRED LIGAMENT	10.0	10.0	10.0	1.0
PINFIRED TENDON	6.0	6.0	6.0	1.0
PERIOSTEAL REACTION	5.0	5.0	5.0	1.0
TRANSPHYSEAL SCREW	7.4	1.0	21.0	13.0
SEQUESTRUM	34.3	1.0	90.0	3.0
SESAMOIDITIS	13.4	1.0	50.0	46.0
SESAMOIDITIS, BONE CYST	12.5	9.0	16.0	2.0
SESAMOINDITIS, JOINT DISTENTION	2.0	2.0	2.0	1.0
SESAMOIDITIS, OCD	5.5	2.0	9.0	2.0
SESAMOIDITIS, OCD, LIGAMENT PROBLEM	8.0	8.0	8.0	1.0
SESAMOIDITIS, OCD, PERIOSTEAL REACTION	5.0	5.0	5.0	1.0
SESAMOIDITIS, PERIOSTEAL REACTION	2.0	2.0	2.0	1.0
SESAMOIDITIS, SPUR	3.0	1.0	5.0	2.0
SESAMOIDITIS, SUSPENSORY PROBLEM	13.5	5.0	22.0	2.0
SESAMOIDITIS, TENDON PROBLEM	6.0	6.0	6.0	1.0
SESAMOIDITIS, TENDON, LIGAMENT PROBLEM	11.0	11.0	11.0	1.0
SPLINT PROBLEM	1.0	1.0	1.0	1.0
SPLINT EXOTOSIS	6.0	6.0	6.0	1.0

SUSPENSORY PROBLEM	5.0	1.0	9.0	8.0
SUSPENSORY PROBLEM, TENDON PROBLEM, OCD	2.0	2.0	2.0	1.0
TENDON PROBLEM	20.9	6.0	85.0	7.0
TENDON PROBLEM (SDF, DDFT)	7.5	6.0	9.0	2.0
TENDON PROBLEM, CHECK LIGAMENT DESMOTOMY	38.0	38.0	38.0	1.0
TENDON PROBLEM, JOINT PROBLEM	16.0	16.0	16.0	1.0
TRAUMA INJURIES NUMEROUS	9.0	9.0	9.0	1.0

	Mean wins	Minimum wins	Maximum Wins	n
ARTHRITIS	1.6	0.0	4.0	5.0
CHECK LIGAMENT DESMOTOMY	4.0	4.0	4.0	1.0
BONE CYST	0.8	0.0	2.0	4.0
BONE CYST, LYSIS	1.0	1.0	1.0	1.0
EPIPHYSITIS	0.5	0.0	1.0	2.0
JOINT DISTENSION	0.0	0.0	0.0	2.0
JOINT FLUSH	2.5	1.0	4.0	2.0
LAMINITIS, OCD, SESAMOIDITIS	1.0	1.0	1.0	1.0
LIGAMENT PROBLEM	0.0	0.0	0.0	1.0
NUMEROUS MSK	0.2	0.0	1.0	5.0
OCD	1.4	0.0	8.0	66.0
OCD, BURSITIS	1.0	1.0	1.0	1.0
OCD, JOINT FLUSH	6.0	6.0	6.0	1.0
OCD, LIGAMENT PROBLEM	1.0	1.0	1.0	1.0
OCD, LOCKING STIFLE	6.0	6.0	6.0	1.0
OCD, PERIOSTEAL ELEVATION	2.0	2.0	2.0	1.0
OCD, TRANSPHYSEAL SCREW	2.0	1.0	3.0	2.0
OCD, SESAMOIDITIS	0.3	0.0	1.0	4.0
OCD,SESAMOIDITIS, PHYSITIS, PERIOSTEAL REACTION	2.0	2.0	2.0	1.0
PEDAL BONE ABNORMALITY	1.0	1.0	1.0	1.0
PINFIRED LIGAMENT	2.0	2.0	2.0	1.0
PINFIRED TENDON	0.0	0.0	0.0	1.0
PERIOSTEAL REACTION	2.0	2.0	2.0	1.0
TRANSPHYSEAL SCREW	0.6	0.0	4.0	13.0
SEQUESTRUM	6.7	0.0	15.0	3.0
SESAMOIDITIS	1.8	0.0	8.0	46.0
SESAMOIDITIS, BONE CYST	1.0	0.0	2.0	2.0
SESAMOINDITIS, JOINT DISTENTION	0.0	0.0	0.0	1.0
SESAMOIDITIS, OCD	2.0	0.0	4.0	2.0
SESAMOIDITIS, OCD, LIGAMENT PROBLEM	1.0	1.0	1.0	1.0
SESAMOIDITIS, OCD, PERIOSTEAL REACTION	1.0	1.0	1.0	1.0
SESAMOIDITIS, PERIOSTEAL REACTION	1.0	1.0	1.0	1.0
SESAMOIDITIS, SPUR	0.0	0.0	0.0	2.0
SESAMOIDITIS, SUSPENSORY PROBLEM	1.0	0.0	2.0	2.0
SESAMOIDITIS, TENDON PROBLEM	0.0	0.0	0.0	1.0
SESAMOIDITIS, TENDON, LIGAMENT	0.0	0.0	0.0	1.0
SPLINT PROBLEM	0.0	0.0	0.0	1.0
SPLINT EXOTOSIS	0.0	0.0	0.0	1.0
SUSPENSORY PROBLEM	1.0	0.0	4.0	8.0
SUSPENSORY PROBLEM, TENDON PROBLEM, OCD	0.0	0.0	0.0	1.0
TENDON PROBLEM	2.7	0.0	8.0	7.0
TENDON PROBLEM (SDF, DDFT)	0.5	0.0	1.0	2.0
TENDON PROBLEM, CHECK LIGAMENT DESMOTOMY	5.0	5.0	5.0	1.0
TENDON PROBLEM, JOINT PROBLEM	4.0	4.0	4.0	1.0
TRAUMA INJURIES NUMEROUS	2.0	2.0	2.0	1.0

	Mean second place	Minimum second place	Maximum second place	n
ARTHRITIS	0.8	0.0	2.0	5.0
CHECK LIGAMENT DESMOTOMY	8.0	8.0	8.0	1.0
BONE CYST	1.5	0.0	3.0	4.0
BONE CYST, LYSIS	3.0	3.0	3.0	1.0
EPIPHYSITIS	0.5	0.0	1.0	2.0
JOINT DISTENSION	0.0	0.0	0.0	2.0
JOINT FLUSH	1.0	1.0	1.0	2.0
LAMINITIS, OCD, SESAMOIDITIS	2.0	2.0	2.0	1.0
LIGAMENT PROBLEM	0.0	0.0	0.0	1.0
NUMEROUS MSK	0.2	0.0	1.0	5.0
OCD	1.3	0.0	9.0	66.0
OCD, BURSITIS	0.0	0.0	0.0	1.0
OCD, JOINT FLUSH	5.0	5.0	5.0	1.0
OCD, LIGAMENT PROBLEM	0.0	0.0	0.0	1.0
OCD, LOCKING STIFLE	5.0	5.0	5.0	1.0
OCD, PERIOSTEAL ELEVATION	1.0	1.0	1.0	1.0
OCD, TRANSPHYSEAL SCREW	1.5	0.0	3.0	2.0
OCD, SESAMOIDITIS	0.8	0.0	1.0	4.0
OCD,SESAMOIDITIS, PHYSITIS, PERIOSTEAL REACTION	0.0	0.0	0.0	1.0
PEDAL BONE ABNORMALITY	2.0	2.0	2.0	1.0
PINFIRED LIGAMENT	2.0	2.0	2.0	1.0
PINFIRED TENDON	0.0	0.0	0.0	1.0
PERIOSTEAL REACTION	1.0	1.0	1.0	1.0
TRANSPHYSEAL SCREW	0.2	0.0	2.0	13.0
SEQUESTRUM	2.7	0.0	6.0	3.0
SESAMOIDITIS	1.3	0.0	5.0	46.0
SESAMOIDITIS, BONE CYST	1.5	1.0	2.0	2.0
SESAMOINDITIS, JOINT DISTENTION	0.0	0.0	0.0	1.0
SESAMOIDITIS, OCD	1.0	0.0	2.0	2.0
SESAMOIDITIS, OCD, LIGAMENT PROBLEM	1.0	1.0	1.0	1.0
SESAMOIDITIS, OCD, PERIOSTEAL REACTION	1.0	1.0	1.0	1.0
SESAMOIDITIS, PERIOSTEAL REACTION	0.0	0.0	0.0	1.0
SESAMOIDITIS, SPUR	1.0	0.0	2.0	2.0
SESAMOIDITIS, SUSPENSORY PROBLEM	1.0	0.0	2.0	2.0
SESAMOIDITIS, TENDON PROBLEM	0.0	0.0	0.0	1.0
SESAMOIDITIS, TENDON, LIGAMENT	0.0	0.0	0.0	1.0
SPLINT PROBLEM	1.0	1.0	1.0	1.0
SPLINT EXOTOSIS	0.0	0.0	0.0	1.0
SUSPENSORY PROBLEM	0.4	0.0	1.0	8.0
SUSPENSORY PROBLEM, TENDON PROBLEM, OCD	0.0	0.0	0.0	1.0
TENDON PROBLEM	3.4	0.0	15.0	7.0
TENDON PROBLEM (SDF, DDFT)	1.5	1.0	2.0	2.0
TENDON PROBLEM, CHECK LIGAMENT DESMOTOMY	3.0	3.0	3.0	1.0
TENDON PROBLEM, JOINT PROBLEM	2.0	2.0	2.0	1.0
TRAUMA INJURIES NUMEROUS	0.0	0.0	0.0	1.0

	Mean third place	Minimum third place	Maximum third place	n
ARTHRITIS	0.6	0.0	1.0	5.0
CHECK LIGAMENT DESMOTOMY	4.0	4.0	4.0	1.0
BONE CYST	1.5	0.0	3.0	4.0
BONE CYST, LYSIS	4.0	4.0	4.0	1.0
EPIPHYSITIS	0.5	0.0	1.0	2.0
JOINT DISTENSION	1.5	1.0	2.0	2.0
JOINT FLUSH	1.5	1.0	2.0	2.0
LAMINITIS, OCD, SESAMOIDITIS	1.0	1.0	1.0	1.0
LIGAMENT PROBLEM	1.0	1.0	1.0	1.0
NUMEROUS MSK	1.4	0.0	4.0	5.0
OCD	1.3	0.0	6.0	66.0
OCD, BURSITIS	1.0	1.0	1.0	1.0
OCD, JOINT FLUSH	3.0	3.0	3.0	1.0
OCD, LIGAMENT PROBLEM	0.0	0.0	0.0	1.0
OCD, LOCKING STIFLE	1.0	1.0	1.0	1.0
OCD, PERIOSTEAL ELEVATION	0.0	0.0	0.0	1.0
OCD, TRANSPHYSEAL SCREW	1.0	1.0	1.0	2.0
OCD, SESAMOIDITIS	0.3	0.0	1.0	4.0
OCD,SESAMOIDITIS, PHYSITIS, PERIOSTEAL REACTION	2.0	2.0	2.0	1.0
PEDAL BONE ABNORMALITY	0.0	0.0	0.0	1.0
PINFIRED LIGAMENT	2.0	2.0	2.0	1.0
PINFIRED TENDON	0.0	0.0	0.0	1.0
PERIOSTEAL REACTION	0.0	0.0	0.0	1.0
TRANSPHYSEAL SCREW	0.8	0.0	3.0	13.0
SEQUESTRUM	1.7	0.0	4.0	3.0
SESAMOIDITIS	1.7	0.0	10.0	46.0
SESAMOIDITIS, BONE CYST	0.5	0.0	1.0	2.0
SESAMOINDITIS, JOINT DISTENTION	1.0	1.0	1.0	1.0
SESAMOIDITIS, OCD	0.5	0.0	1.0	2.0
SESAMOIDITIS, OCD, LIGAMENT PROBLEM	3.0	3.0	3.0	1.0
SESAMOIDITIS, OCD, PERIOSTEAL REACTION	2.0	2.0	2.0	1.0
SESAMOIDITIS, PERIOSTEAL REACTION	0.0	0.0	0.0	1.0
SESAMOIDITIS, SPUR	0.5	0.0	1.0	2.0
SESAMOIDITIS, SUSPENSORY PROBLEM	0.5	0.0	1.0	2.0
SESAMOIDITIS, TENDON PROBLEM	1.0	1.0	1.0	1.0
SESAMOIDITIS, TENDON, LIGAMENT	2.0	2.0	2.0	1.0
SPLINT PROBLEM	0.0	0.0	0.0	1.0
SPLINT EXOTOSIS	0.0	0.0	0.0	1.0
SUSPENSORY PROBLEM	0.9	0.0	3.0	8.0
SUSPENSORY PROBLEM, TENDON PROBLEM, OCD	0.0	0.0	0.0	1.0
TENDON PROBLEM	2.4	0.0	8.0	7.0
TENDON PROBLEM (SDF, DDFT)	1.0	0.0	2.0	2.0
TENDON PROBLEM, CHECK LIGAMENT DESMOTOMY	4.0	4.0	4.0	1.0
TENDON PROBLEM, JOINT PROBLEM	4.0	4.0	4.0	1.0
TRAUMA INJURIES NUMEROUS	2.0	2.0	2.0	1.0

	Mean winnings	Minimum winnings	Maximum winnings	n
ARTHRITIS	£14,691.60	£0.00	£50,120.00	5.0
CHECK LIGAMENT DESMOTOMY	£22,398.00	£22,398.00	£22,398.00	1.0
BONE CYST	£3,641.00	£0.00	£7,367.00	4.0
BONE CYST, LYSIS	£3,445.00	£3,445.00	£3,445.00	1.0
EPIPHYSITIS	£2,743.00	£0.00	£5,486.00	2.0
JOINT DISTENSION	£0.00	£0.00	£0.00	2.0
JOINT FLUSH	£7,845.50	£4,794.00	£10,897.00	2.0
LAMINITIS, OCD, SESAMOIDITIS	£2,961.00	£2,961.00	£2,961.00	1.0
LIGAMENT PROBLEM	£0.00	£0.00	£0.00	1.0
NUMEROUS MSK	£583.00	£0.00	£2,915.00	5.0
OCD	£13,510.02	£0.00	£224,348.00	66.0
OCD, BURSITIS	£4,866.00	£4,866.00	£4,866.00	1.0
OCD, JOINT FLUSH	£37,026.00	£37,026.00	£37,026.00	1.0
OCD, LIGAMENT PROBLEM	£4,380.00	£4,380.00	£4,380.00	1.0
OCD, LOCKING STIFLE	£29,671.00	£29,671.00	£29,671.00	1.0
OCD, PERIOSTEAL ELEVATION	£17,533.00	£17,533.00	£17,533.00	1.0
OCD, TRANSPHYSEAL SCREW	£7,039.00	£2,389.00	£11,689.00	2.0
OCD, SESAMOIDITIS	£914.00	£0.00	£3,656.00	4.0
OCD,SESAMOIDITIS, PHYSITIS, PERIOSTEAL REACTION	£14,771.00	£14,771.00	£14,771.00	1.0
PEDAL BONE ABNORMALITY	£4,056.00	£4,056.00	£4,056.00	1.0
PINFIRED LIGAMENT	£9,963.00	£9,963.00	£9,963.00	1.0
PINFIRED TENDON	£0.00	£0.00	£0.00	1.0
PERIOSTEAL REACTION	£20,169.00	£20,169.00	£20,169.00	1.0
TRANSPHYSEAL SCREW	£4,436.46	£0.00	£45,682.00	13.0
SEQUESTRUM	£57,249.00	£0.00	£109,304.00	3.0
SESAMOIDITIS	£25,683.39	£0.00	£473,166.00	46.0
SESAMOIDITIS, BONE CYST	£7,927.00	£0.00	£15,854.00	2.0
SESAMOINDITIS, JOINT DISTENTION	£0.00	£0.00	£0.00	1.0
SESAMOIDITIS, OCD	£183,568.00	£0.00	£367,136.00	2.0
SESAMOIDITIS, OCD, LIGAMENT PROBLEM	£3,886.00	£3,886.00	£3,886.00	1.0
SESAMOIDITIS, OCD, PERIOSTEAL REACTION	£2,674.00	£2,674.00	£2,674.00	1.0
SESAMOIDITIS, PERIOSTEAL REACTION	£7,095.00	£7,095.00	£7,095.00	1.0
SESAMOIDITIS, SPUR	£0.00	£0.00	£0.00	2.0
SESAMOIDITIS, SUSPENSORY PROBLEM	£2,878.00	£0.00	£5,756.00	2.0
SESAMOIDITIS, TENDON PROBLEM	£0.00	£0.00	£0.00	1.0
SESAMOIDITIS, TENDON, LIGAMENT	£0.00	£0.00	£0.00	1.0
SPLINT PROBLEM	£0.00	£0.00	£0.00	1.0
SPLINT EXOTOSIS	£0.00	£0.00	£0.00	1.0
SUSPENSORY PROBLEM	£4,791.75	£0.00	£15,518.00	8.0
SUSPENSORY PROBLEM, TENDON PROBLEM, OCD	£0.00	£0.00	£0.00	1.0
TENDON PROBLEM	£11,707.43	£0.00	£21,760.00	7.0
TENDON PROBLEM (SDF, DDFT)	£5,743.00	£0.00	£11,486.00	2.0
TENDON PROBLEM, CHECK LIGAMENT DESMOTOMY	£40,046.00	£40,046.00	£40,046.00	1.0
TENDON PROBLEM, JOINT PROBLEM	£15,000.00	£15,000.00	£15,000.00	1.0
TRAUMA INJURIES NUMEROUS	£14,855.00	£14,855.00	£14,855.00	1.0

	Mean earnings	Minimum earnings	Maximum earnings	n
ARTHRITIS	£20,514.60	£0.00	£55,620.00	5.00
CHECK LIGAMENT DESMOTOMY	£44,543.00	£44,543.00	£44,543.00	1.00
BONE CYST	£8,201.25	£2,621.00	£14,396.00	4.00
BONE CYST, LYSIS	£19,312.00	£19,312.00	£19,312.00	1.00
EPIPHYSITIS	£3,581.00	£353.00	£6,809.00	2.00
JOINT DISTENSION	£805.50	£648.00	£963.00	2.00
JOINT FLUSH	£11,918.00	£8,631.00	£15,205.00	2.00
LAMINITIS, OCD, SESAMOIDITIS	£6,712.00	£6,712.00	£6,712.00	1.00
LIGAMENT PROBLEM	£532.00	£532.00	£532.00	1.00
NUMEROUS MSK	£1,830.80	£0.00	£3,810.00	5.00
OCD	£24,461.32	£0.00	£371,468.00	66.00
OCD, BURSITIS	£8,059.00	£8,059.00	£8,059.00	1.00
OCD, JOINT FLUSH	£61,001.00	£61,001.00	£61,001.00	1.00
OCD, LIGAMENT PROBLEM	£4,668.00	£4,668.00	£4,668.00	1.00
OCD, LOCKING STIFLE	£43,601.00	£43,601.00	£43,601.00	1.00
OCD, PERIOSTEAL ELEVATION	£29,137.00	£29,137.00	£29,137.00	1.00
OCD, TRANSPHYSEAL SCREW	£9,297.00	£2,967.00	£15,627.00	2.00
OCD, SESAMOIDITIS	£2,300.25	£0.00	£4,591.00	4.00
OCD,SESAMOIDITIS, PHYSITIS, PERIOSTEAL REACTION	£17,534.00	£17,534.00	£17,534.00	1.00
PEDAL BONE ABNORMALITY	£6,402.00	£6,402.00	£6,402.00	1.00
PINFIRED LIGAMENT	£16,854.00	£16,854.00	£16,854.00	1.00
PINFIRED TENDON	£0.00	£0.00	£0.00	1.00
PERIOSTEAL REACTION	£26,481.00	£26,481.00	£26,481.00	1.00
TRANSPHYSEAL SCREW	£6,259.92	£0.00	£56,151.00	13.00
SEQUESTRUM	£76,524.00	£0.00	£153,166.00	3.00
SESAMOIDITIS	£36,589.46	£0.00	£495,759.00	46.00
SESAMOIDITIS, BONE CYST	£12,224.50	£1,795.00	£22,654.00	2.00
SESAMOINDITIS, JOINT DISTENTION	£1,656.00	£1,656.00	£1,656.00	1.00
SESAMOIDITIS, OCD	£216,868.50	£0.00	£433,737.00	2.00
SESAMOIDITIS, OCD, LIGAMENT PROBLEM	£14,583.00	£14,583.00	£14,583.00	1.00
SESAMOIDITIS, OCD, PERIOSTEAL REACTION	£5,502.00	£5,502.00	£5,502.00	1.00
SESAMOIDITIS, PERIOSTEAL REACTION	£7,095.00	£7,095.00	£7,095.00	1.00
SESAMOIDITIS, SPUR	£2,001.00	£0.00	£4,002.00	2.00
SESAMOIDITIS, SUSPENSORY PROBLEM	£5,936.50	£0.00	£11,873.00	2.00
SESAMOIDITIS, TENDON PROBLEM	£895.00	£895.00	£895.00	1.00
SESAMOIDITIS, TENDON, LIGAMENT	£891.00	£891.00	£891.00	1.00
SPLINT PROBLEM	£2,553.00	£2,553.00	£2,553.00	1.00
SPLINT EXOTOSIS	£0.00	£0.00	£0.00	1.00
SUSPENSORY PROBLEM	£7,657.00	£0.00	£30,618.00	8.00
SUSPENSORY PROBLEM, TENDON PROBLEM, OCD	£0.00	£0.00	£0.00	1.00
TENDON PROBLEM	£20,595.14	£1,807.00	£43,910.00	7.00
TENDON PROBLEM (SDF, DDFT)	£10,782.50	£2,120.00	£19,445.00	2.00
TENDON PROBLEM, CHECK LIGAMENT DESMOTOMY	£66,395.00	£66,395.00	£66,395.00	1.00
TENDON PROBLEM, JOINT PROBLEM	£42,782.00	£42,782.00	£42,782.00	1.00
TRAUMA INJURIES NUMEROUS	£19,293.00	£19,293.00	£19,293.00	1.00

	Minimum Racing Post rating	Maximum Racing Post rating	Minimum Official rating	Maximum Official rating
ARTHRITIS	66	116	70	110
CHECK LIGAMENT DESMOTOMY	87	128	80	116
BONE CYST	64	125	67	100
BONE CYST, LYSIS	56	110	65	66
EPIPHYSITIS	58	90	39	94
JOINT DISTENSION	64	72	64	69
JOINT FLUSH	80	103	72	106
LAMINITIS, OCD, SESAMOIDITIS	76	76	65	65
LIGAMENT PROBLEM	59	65	58	58
NUMEROUS MSK	16	70	60	72
OCD	7	135	37	132
OCD, BURSITIS	54	93	31	90
OCD, JOINT FLUSH	86	102	72	86
OCD, LIGAMENT PROBLEM	44	54	40	40
OCD, LOCKING STIFLE	93	133	72	127
OCD, PERIOSTEAL ELEVATION	105	105		
OCD, TRANSPHYSEAL SCREW	48	105	65	110
OCD, SESAMOIDITIS	68	88	45	82
OCD,SESAMOIDITIS, PHYSITIS, PERIOSTEAL REACTION	84	108	105	105
PEDAL BONE ABNORMALITY	81	81	83	83
PINFIRED LIGAMENT	121	121		
PINFIRED TENDON	45	59	54	59
PERIOSTEAL REACTION	101	101	100	100
TRANSPHYSEAL SCREW	15	130	40	115
SEQUESTRUM	50	113	62	63
SESAMOIDITIS	41	131	37	127
SESAMOIDITIS, BONE CYST	45	97	48	92
SESAMOINDITIS, JOINT DISTENTION				
SESAMOIDITIS, OCD	131	131	125	125
SESAMOIDITIS, OCD, LIGAMENT PROBLEM	99	103	91	98
SESAMOIDITIS, OCD, PERIOSTEAL REACTION	78	78	76	76
SESAMOIDITIS, PERIOSTEAL REACTION	88	88		
SESAMOIDITIS, SPUR	69	75	70	70
SESAMOIDITIS, SUSPENSORY PROBLEM	73	82	55	87
SESAMOIDITIS, TENDON PROBLEM	66	66	60	60
SESAMOIDITIS, TENDON, LIGAMENT	46	71	45	49
SPLINT PROBLEM	70	70		
SPLINT EXOTOSIS	17	41	39	45
SUSPENSORY PROBLEM	47	101	52	79
SUSPENSORY PROBLEM, TENDON PROBLEM, OCD	24	24		
TENDON PROBLEM	42	153	46	144
TENDON PROBLEM (SDF, DDFT)	26	98	47	55
TENDON PROBLEM, CHECK LIGAMENT DESMOTOMY	63	91	79	80
TENDON PROBLEM, JOINT PROBLEM	84	97		
TRAUMA INJURIES NUMEROUS	95	95	82	82

4.2 Fracture (n = 103)

Type	Mean starts	Minimum starts	Maximum starts	n
METATARSAL III	3.0	3.0	3.0	1.0
METACARPAL III	90.0	90.0	90.0	1.0
FETLOCK	11.2	1.0	35.0	9.0
TARSUS	4.0	1.0	8.0	4.0
MANDIBLE	1.0	1.0	1.0	1.0
NASAL BONE	3.0	3.0	3.0	1.0
NAVICULAR	7.0	2.0	12.0	2.0
PEDAL BONE, FETLOCK	10.0	10.0	10.0	1.0
PROXIMAL PHALANX	4.0	4.0	4.0	1.0
PEDAL BONE	7.0	1.0	18.0	5.0
PELVIS	1.0	1.0	1.0	1.0
RIB	4.0	4.0	4.0	1.0
PROXIMAL SESAMOID	9.2	1.0	50.0	16.0
CRANIUM	37.0	37.0	37.0	1.0
SPLINT	22.2	2.0	70.0	5.0
SPLINT, NAVICULAR BONE	15.0	15.0	15.0	1.0
TIBIA	24.0	24.0	24.0	1.0

Type	Mean wins	Minimum wins	Maximum Wins	n
METATARSAL III	2.0	2.0	2.0	1.0
METACARPAL III	15.0	15.0	15.0	1.0
FETLOCK	1.0	0.0	3.0	9.0
TARSUS	0.0	0.0	0.0	4.0
MANDIBLE	0.0	0.0	0.0	1.0
NASAL BONE	0.0	0.0	0.0	1.0
NAVICULAR	0.5	0.0	1.0	2.0
PEDAL BONE, FETLOCK	2.0	2.0	2.0	1.0
PROXIMAL PHALANX	1.0	1.0	1.0	1.0
PEDAL BONE	1.8	0.0	5.0	5.0
PELVIS	0.0	0.0	0.0	1.0
RIB	1.0	1.0	1.0	1.0
PROXIMAL SESAMOID	0.6	0.0	2.0	16.0
CRANIUM	3.0	3.0	3.0	1.0
SPLINT	2.4	0.0	8.0	5.0
SPLINT, NAVICULAR BONE	0.0	0.0	0.0	1.0
TIBIA	5.0	5.0	5.0	1.0

Type	Mean second place	Minimum second place	Maximum second place	n
METATARSAL III	1.0	1.0	1.0	1.0
METACARPAL III	6.0	6.0	6.0	1.0
FETLOCK	1.3	0.0	3.0	9.0
TARSUS	0.3	0.0	1.0	4.0
MANDIBLE	0.0	0.0	0.0	1.0
NASAL BONE	0.0	0.0	0.0	1.0
NAVICULAR	0.0	0.0	0.0	2.0
PEDAL BONE, FETLOCK	2.0	2.0	2.0	1.0
PROXIMAL PHALANX	0.0	0.0	0.0	1.0
PEDAL BONE	1.0	0.0	2.0	5.0
PELVIS	0.0	0.0	0.0	1.0
RIB	0.0	0.0	0.0	1.0
PROXIMAL SESAMOID	0.8	0.0	3.0	16.0
CRANIUM	2.0	2.0	2.0	1.0
SPLINT	1.8	0.0	7.0	5.0
SPLINT, NAVICULAR BONE	1.0	1.0	1.0	1.0
TIBIA	3.0	3.0	3.0	1.0

Type	Mean third place	Minimum third place	Maximum third place	n
METATARSAL III	0.0	0.0	0.0	1.0
METACARPAL III	4.0	4.0	4.0	1.0
FETLOCK	1.2	0.0	6.0	9.0
TARSUS	0.0	0.0	0.0	4.0
MANDIBLE	0.0	0.0	0.0	1.0
NASAL BONE	0.0	0.0	0.0	1.0
NAVICULAR	0.0	0.0	0.0	2.0
PEDAL BONE, FETLOCK	2.0	2.0	2.0	1.0
PROXIMAL PHALANX	0.0	0.0	0.0	1.0
PEDAL BONE	0.6	0.0	1.0	5.0
PELVIS	0.0	0.0	0.0	1.0
RIB	0.0	0.0	0.0	1.0
PROXIMAL SESAMOID	1.1	0.0	4.0	16.0
CRANIUM	2.0	2.0	2.0	1.0
SPLINT	3.0	1.0	6.0	5.0
SPLINT, NAVICULAR BONE	4.0	4.0	4.0	1.0
TIBIA	5.0	5.0	5.0	1.0

	Mean winnings	Minimum winnings	Maximum winnings	n
METATARSAL III	£16,064.00	£16,064.00	£16,064.00	1.0
METACARPAL III	£62,443.00	£62,443.00	£62,443.00	1.0
FETLOCK	£9,068.56	£0.00	£51,928.00	9.0
TARSUS	£0.00	£0.00	£0.00	4.0
MANDIBLE	£0.00	£0.00	£0.00	1.0
NASAL BONE	£0.00	£0.00	£0.00	1.0
NAVICULAR	£2,190.00	£0.00	£4,380.00	2.0
PEDAL BONE, FETLOCK	£9,963.00	£9,963.00	£9,963.00	1.0
PROXIMAL PHALANX	£6,383.00	£6,383.00	£6,383.00	1.0
PEDAL BONE	£33,622.80	£0.00	£115,047.00	5.0
PELVIS	£0.00	£0.00	£0.00	1.0
RIB	£2,048.00	£2,048.00	£2,048.00	1.0
PROXIMAL SESAMOID	£2,935.56	£0.00	£12,522.00	16.0
CRANIUM	£9,981.00	£9,981.00	£9,981.00	1.0
SPLINT	£16,922.40	£0.00	£62,767.00	5.0
SPLINT, NAVICULAR BONE	£0.00	£0.00	£0.00	1.0
TIBIA	£68,600.00	£68,600.00	£68,600.00	1.0

	Mean earnings	Minimum earnings	Maximum earnings	n
METATARSAL III	£16,863.00	£16,863.00	£16,863.00	1.0
METACARPAL III	£76,406.00	£76,406.00	£76,406.00	1.0
FETLOCK	£17,971.56	£0.00	£98,724.00	9.0
TARSUS	£594.50	£0.00	£1,525.00	4.0
MANDIBLE	£0.00	£0.00	£0.00	1.0
NASAL BONE	£255.00	£255.00	£255.00	1.0
NAVICULAR	£2,334.00	£0.00	£4,668.00	2.0
PEDAL BONE, FETLOCK	£16,854.00	£16,854.00	£16,854.00	1.0
PROXIMAL PHALANX	£11,348.00	£11,348.00	£11,348.00	1.0
PEDAL BONE	£41,319.00	£0.00	£131,307.00	5.0
PELVIS	£0.00	£0.00	£0.00	1.0
RIB	£2,048.00	£2,048.00	£2,048.00	1.0
PROXIMAL SESAMOID	£6,373.06	£0.00	£21,169.00	16.0
CRANIUM	£15,800.00	£15,800.00	£15,800.00	1.0
SPLINT	£28,348.60	£8,345.00	£95,578.00	5.0
SPLINT, NAVICULAR BONE	£5,462.00	£5,462.00	£5,462.00	1.0
TIBIA	£183,782.00	£183,782.00	£183,782.00	1.0

	Minimum Racing Post rating	Maximum Racing Post rating	Minimum Official rating	Maximum Official rating
METATARSAL III	116	116	-	-
METACARPAL III	80	101	62	63
FETLOCK	36	116	45	99
TARSUS	42	80	45	55
MANDIBLE	50	50	-	-
NASAL BONE	53	53	-	-
NAVICULAR	44	54	40	40
PEDAL BONE, FETLOCK	121	121	-	-
PROXIMAL PHALANX	98	98	-	-
PEDAL BONE	47	119	82	94
PELVIS	-	-	-	-
RIB	50	61	54	56
PROXIMAL SESAMOID	31	100	30	91
CRANIUM	71	92	55	82
SPLINT	82	102	65	71
SPLINT, NAVICULAR BONE	76	77	72	72
TIBIA	116	116	-	-

4.3 Respiratory (n = 91)

type	Mean starts	Minimum starts	Maximum starts	n
BRONCHITIS	46.0	46.0	46.0	1.0
COUGH	12.0	2.0	27.0	6.0
GUTTORAL PUCH MYCOSIS	5.0	5.0	5.0	1.0
IMMATURE LARYNX, NASAL DISCHARGE, COUGH	15.0	15.0	15.0	1.0
LARYNX	23.2	1.0	50.0	9.0
LARYNX, DDSP	3.0	3.0	3.0	1.0
LARYNX, DDSP/PALATE	5.0	5.0	5.0	1.0
LARYNX, GUTTORAL POUCH ABCESS	1.0	1.0	1.0	1.0
LARYNX, NASAL DISCHARGE	15.5	10.0	21.0	2.0
LARYNX, NASAL DISCHARGE, COUGH, PHARYNGITIS	55.0	55.0	55.0	1.0
LARYNX, PALATE INSTABILITY	10.0	4.0	16.0	2.0
NASAL FRACTURE	3.0	3.0	3.0	1.0
NASAL DISCHARGE	7.7	1.0	24.0	10.0
NASAL DISCHARGE, COUGH	11.8	5.0	20.0	4.0
NASAL DISCHARGE, COUGH, VENTIPULMIN LESION	5.0	5.0	5.0	1.0
PALATE INSTABILITY	15.2	1.0	46.0	5.0
PALATE INSTABILITY, NSD	2.0	2.0	2.0	1.0
PALATE INSTABILITY, PHARYNGEAL LYMPHOID HYPERPLASIA	8.0	8.0	8.0	1.0
PALATE INSTABILITY, PHARYNGEAL LYMPHOID HYPERPLASIA, NARROW AIRWAY	25.0	25.0	25.0	1.0
PHARYNGITIS	6.0	6.0	6.0	1.0
SINUSITIS	8.0	8.0	8.0	1.0
UPPER RESPIRATORY INFECTION	13.7	3.0	34.0	3.0

	Mean wins	Minimum wins	Maximum Wins	n
BRONCHITIS	5.0	5.0	5.0	1.0
COUGH	2.2	0.0	5.0	6.0
GUTTORAL PUCH MYCOSIS	0.0	0.0	0.0	1.0
IMMATURE LARYNX, NASAL DISCHARGE, COUGH	7.0	7.0	7.0	1.0
LARYNX	2.9	0.0	8.0	9.0
LARYNX, DDSP	0.0	0.0	0.0	1.0
LARYNX, DDSP/PALATE	0.0	0.0	0.0	1.0
LARYNX, GUTTORAL POUCH ABCESS	0.0	0.0	0.0	1.0
LARYNX, NASAL DISCHARGE	3.0	2.0	4.0	2.0
LARYNX, NASAL DISCHARGE, COUGH, PHARYNGITIS	6.0	6.0	6.0	1.0
LARYNX, PALATE INSTABILITY	0.0	0.0	0.0	2.0
NASAL FRACTURE	0.0	0.0	0.0	1.0
NASAL DISCHARGE	1.4	0.0	5.0	10.0
NASAL DISCHARGE, COUGH	0.5	0.0	1.0	4.0
NASAL DISCHARGE, COUGH, VENTIPULMIN LESION	1.0	1.0	1.0	1.0
PALATE INSTABILITY	2.2	0.0	9.0	5.0
PALATE INSTABILITY, NSD	0.0	0.0	0.0	1.0
PALATE INSTABILITY, PHARYNGEAL LYMPHOID HYPERPLASIA	2.0	2.0	2.0	1.0
PALATE INSTABILITY, PHARYNGEAL LYMPHOID HYPERPLASIA, NARROW AIRWAY	0.0	0.0	0.0	1.0
PHARYNGITIS	0.0	0.0	0.0	1.0
SINUSITIS	1.0	1.0	1.0	1.0
UPPER RESPIRATORY INFECTION	1.0	0.0	2.0	3.0

	Mean second place	Minimum second place	Maximum second place	n
BRONCHITIS	6.0	6.0	6.0	1.0
COUGH	1.0	0.0	2.0	6.0
GUTTORAL PUCH MYCOSIS	0.0	0.0	0.0	1.0
IMMATURE LARYNX, NASAL DISCHARGE, COUGH	4.0	4.0	4.0	1.0
LARYNX	2.2	0.0	5.0	9.0
LARYNX, DDSP	1.0	1.0	1.0	1.0
LARYNX, DDSP/PALATE	2.0	2.0	2.0	1.0
LARYNX, GUTTORAL POUCH ABCESS	0.0	0.0	0.0	1.0
LARYNX, NASAL DISCHARGE	2.0	2.0	2.0	2.0
LARYNX, NASAL DISCHARGE, COUGH, PHARYNGITIS	10.0	10.0	10.0	1.0
LARYNX, PALATE INSTABILITY	1.5	1.0	2.0	2.0
NASAL FRACTURE	0.0	0.0	0.0	1.0
NASAL DISCHARGE	1.5	0.0	7.0	10.0
NASAL DISCHARGE, COUGH	0.8	0.0	1.0	4.0
NASAL DISCHARGE, COUGH, VENTIPULMIN LESION	0.0	0.0	0.0	1.0
PALATE INSTABILITY	1.0	0.0	3.0	5.0
PALATE INSTABILITY, NSD	0.0	0.0	0.0	1.0
PALATE INSTABILITY, PHARYNGEAL LYMPHOID HYPERPLASIA	4.0	4.0	4.0	1.0
PALATE INSTABILITY, PHARYNGEAL LYMPHOID HYPERPLASIA, NARROW AIRWAY	2.0	2.0	2.0	1.0
PHARYNGITIS	2.0	2.0	2.0	1.0
SINUSITIS	2.0	2.0	2.0	1.0
UPPER RESPIRATORY INFECTION	1.0	0.0	2.0	3.0

	Mean third place	Minimum third place	Maximum third place	n
BRONCHITIS	4.0	4.0	4.0	1.0
COUGH	1.2	0.0	4.0	6.0
GUTTORAL PUCH MYCOSIS	0.0	0.0	0.0	1.0
IMMATURE LARYNX, NASAL DISCHARGE, COUGH	0.0	0.0	0.0	1.0
LARYNX	3.1	0.0	10.0	9.0
LARYNX, DDSP	2.0	2.0	2.0	1.0
LARYNX, DDSP/PALATE	0.0	0.0	0.0	1.0
LARYNX, GUTTORAL POUCH ABCESS	0.0	0.0	0.0	1.0
LARYNX, NASAL DISCHARGE	2.0	0.0	4.0	2.0
LARYNX, NASAL DISCHARGE, COUGH, PHARYNGITIS	12.0	12.0	12.0	1.0
LARYNX, PALATE INSTABILITY	1.5	0.0	3.0	2.0
NASAL FRACTURE	0.0	0.0	0.0	1.0
NASAL DISCHARGE	1.2	0.0	5.0	10.0
NASAL DISCHARGE, COUGH	1.3	0.0	3.0	4.0
NASAL DISCHARGE, COUGH, VENTIPULMIN LESION	1.0	1.0	1.0	1.0
PALATE INSTABILITY	0.6	0.0	3.0	5.0
PALATE INSTABILITY, NSD	0.0	0.0	0.0	1.0
PALATE INSTABILITY, PHARYNGEAL LYMPHOID HYPERPLASIA	1.0	1.0	1.0	1.0
PALATE INSTABILITY, PHARYNGEAL LYMPHOID HYPERPLASIA, NARROW AIRWAY	4.0	4.0	4.0	1.0
PHARYNGITIS	3.0	3.0	3.0	1.0
SINUSITIS	2.0	2.0	2.0	1.0
UPPER RESPIRATORY INFECTION	0.3	0.0	1.0	3.0

	Mean winnings	Minimum winnings	Maximum winnings	n
BRONCHITIS	£11,849.00	£11,849.00	£11,849.00	1.0
COUGH	£15,862.50	£0.00	£40,629.00	6.0
GUTTORAL PUCH MYCOSIS	£0.00	£0.00	£0.00	1.0
IMMATURE LARYNX, NASAL DISCHARGE, COUGH	£170,398.00	£170,398.00	£170,398.00	1.0
LARYNX	£131,232.33	£0.00	£1,070,413.00	9.0
LARYNX, DDSP	£0.00	£0.00	£0.00	1.0
LARYNX, DDSP/PALATE	£0.00	£0.00	£0.00	1.0
LARYNX, GUTTORAL POUCH ABCESS	£0.00	£0.00	£0.00	1.0
LARYNX, NASAL DISCHARGE	£32,060.00	£11,377.00	£52,743.00	2.0
LARYNX, NASAL DISCHARGE, COUGH, PHARYNGITIS	£14,188.00	£14,188.00	£14,188.00	1.0
LARYNX, PALATE INSTABILITY	£0.00	£0.00	£0.00	2.0
NASAL FRACTURE	£0.00	£0.00	£0.00	1.0
NASAL DISCHARGE	£11,453.10	£0.00	£68,600.00	10.0
NASAL DISCHARGE, COUGH	£1,371.75	£0.00	£3,868.00	4.0
NASAL DISCHARGE, COUGH, VENTIPULMIN LESION	£6,552.00	£6,552.00	£6,552.00	1.0
PALATE INSTABILITY	£10,793.20	£0.00	£30,173.00	5.0
PALATE INSTABILITY, NSD	£0.00	£0.00	£0.00	1.0
PALATE INSTABILITY, PHARYNGEAL LYMPHOID HYPERPLASIA	£13,923.00	£13,923.00	£13,923.00	1.0
PALATE INSTABILITY, PHARYNGEAL LYMPHOID HYPERPLASIA, NARROW AIRWAY	£0.00	£0.00	£0.00	1.0
PHARYNGITIS	£0.00	£0.00	£0.00	1.0
SINUSITIS	£4,368.00	£4,368.00	£4,368.00	1.0
UPPER RESPIRATORY INFECTION	£4,471.33	£0.00	£7,863.00	3.0

	Mean earnings	Minimum earnings	Maximum earnings	n
BRONCHITIS	£17,864.00	£17,864.00	£17,864.00	1.0
COUGH	£22,730.50	£0.00	£55,860.00	6.0
GUTTORAL PUCH MYCOSIS	£279.00	£279.00	£279.00	1.0
IMMATURE LARYNX, NASAL DISCHARGE, COUGH	£276,489.00	£276,489.00	£276,489.00	1.0
LARYNX	£139,177.44	£0.00	£1,074,965.00	9.0
LARYNX, DDSP	£8,071.00	£8,071.00	£8,071.00	1.0
LARYNX, DDSP/PALATE	£2,294.00	£2,294.00	£2,294.00	1.0
LARYNX, GUTTORAL POUCH ABCESS	£0.00	£0.00	£0.00	1.0
LARYNX, NASAL DISCHARGE	£45,600.00	£25,216.00	£65,984.00	2.0
LARYNX, NASAL DISCHARGE, COUGH, PHARYNGITIS	£27,710.00	£27,710.00	£27,710.00	1.0
LARYNX, PALATE INSTABILITY	£3,044.50	£964.00	£5,125.00	2.0
NASAL FRACTURE	£255.00	£255.00	£255.00	1.0
NASAL DISCHARGE	£29,009.60	£0.00	£183,782.00	10.0
NASAL DISCHARGE, COUGH	£5,485.75	£0.00	£17,508.00	4.0
NASAL DISCHARGE, COUGH, VENTIPULMIN LESION	£11,035.00	£11,035.00	£11,035.00	1.0
PALATE INSTABILITY	£15,468.60	£0.00	£37,272.00	5.0
PALATE INSTABILITY, NSD	£942.00	£942.00	£942.00	1.0
PALATE INSTABILITY, PHARYNGEAL LYMPHOID HYPERPLASIA	£29,731.00	£29,731.00	£29,731.00	1.0
PALATE INSTABILITY, PHARYNGEAL LYMPHOID HYPERPLASIA, NARROW AIRWAY	£2,578.00	£2,578.00	£2,578.00	1.0
PHARYNGITIS	£12,521.00	£12,521.00	£12,521.00	1.0
SINUSITIS	£39,588.00	£39,588.00	£39,588.00	1.0
UPPER RESPIRATORY INFECTION	£6,019.67	£0.00	£10,673.00	3.0

	Minimum Racing Post rating	Maximum Racing Post rating	Minimum Official rating	Maximum Official rating
BRONCHITIS	65	70	45	55
COUGH	47	119	63	119
GUTTORAL PUCH MYCOSIS	73	73	72	72
IMMATURE LARYNX, NASAL DISCHARGE, COUGH	119	119	113	113
LARYNX	30	131	45	121
LARYNX, DDSP	75	75		
LARYNX, DDSP/PALATE	65	68	72	74
LARYNX, GUTTORAL POUCH ABCESS	69	69		
LARYNX, NASAL DISCHARGE	76	111	82	106
LARYNX, NASAL DISCHARGE, COUGH, PHARYNGITIS	64	80	74	74
LARYNX, PALATE INSTABILITY	8	101	53	70
NASAL FRACTURE	53	53		
NASAL DISCHARGE	30	153	54	144
NASAL DISCHARGE, COUGH	48	105	60	104
NASAL DISCHARGE, COUGH, VENTIPULMIN LESION	85	93		
PALATE INSTABILITY	45	105	45	60
PALATE INSTABILITY, NSD	87	87		
PALATE INSTABILITY, PHARYNGEAL LYMPHOID HYPERPLASIA	106	106	105	105
PALATE INSTABILITY, PHARYNGEAL LYMPHOID HYPERPLASIA, NARROW AIRWAY	34	89	26	91
PHARYNGITIS	82	82		
SINUSITIS	109	109	109	109
UPPER RESPIRATORY INFECTION	28	103	40	88

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